



LIVING THE DREAM: ESTABLISHING A COLONY ON MARS p. 26

SCIENCE ILLUSTRATED

**RECLAIMING
LOUISIANA
HOLDING
BACK THE BAY**

**WINDY CITIES
TURBINES OF
TOMORROW**

**WATER, WATER
EVERYWHERE
HOW THE
PLANET STAYS
HYDRATED**



**PREDATORS
IN PERIL**
p. 34

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The resident astronauts of the International Space Station get a different view of the planet.



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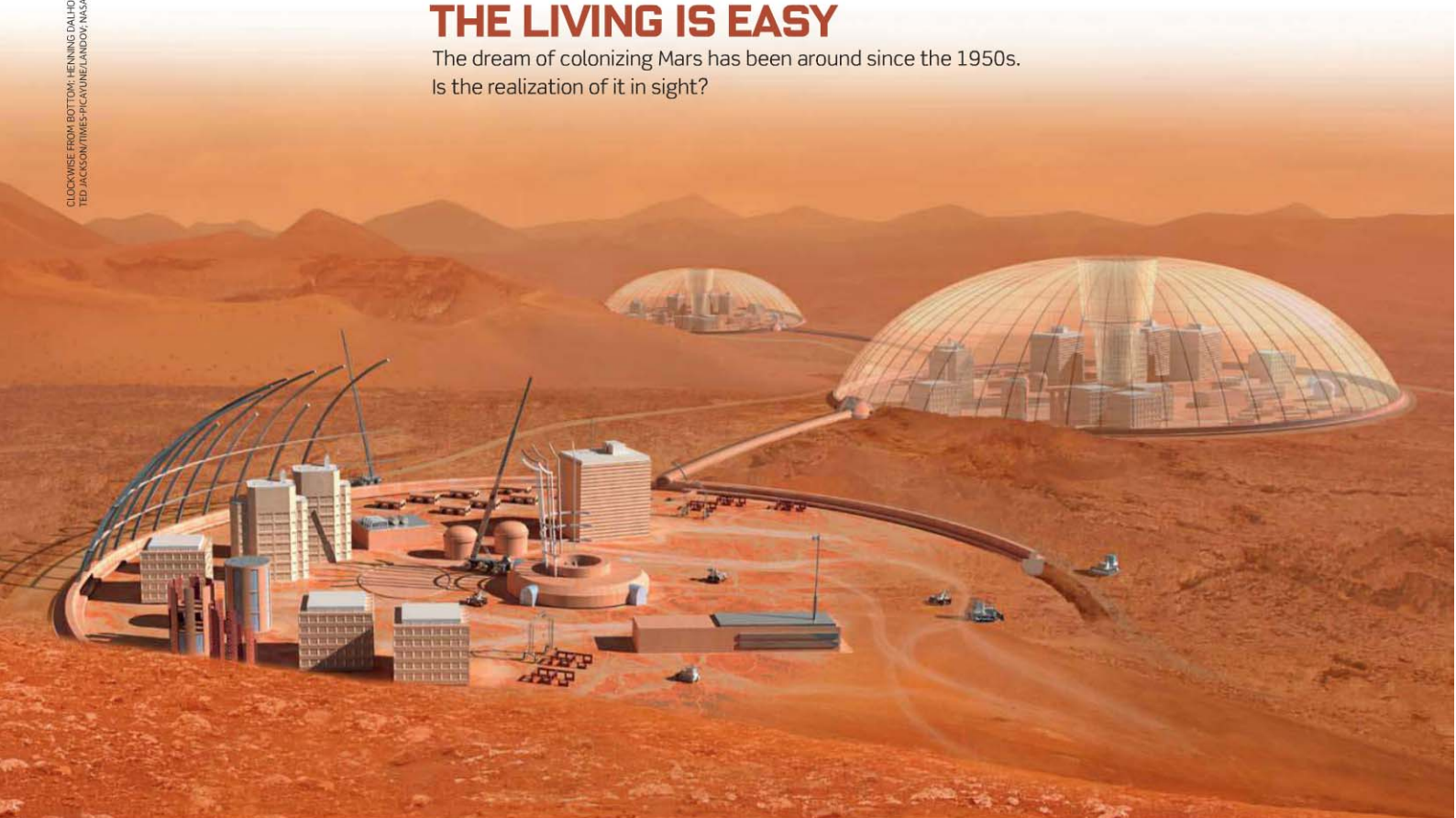
PREDATORS IN PERIL

When top predators disappear, the whole food chain suffers.

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THE LIVING IS EASY

The dream of colonizing Mars has been around since the 1950s. Is the realization of it in sight?



CLOCKWISE FROM BOTTOM: HENNING DALHOFF; J.F. BAGASCANPIX; TED JACKSON/TIMES-PICAYUNE/LANDOV; NASA; NATURE PL.

DEPARTMENTS



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BULL'S-EYE

This month's gallery of amazing images: a peephole in Greenland, a colorful artist, breast cancer up close and a bright way to search for dark matter.



SCIENCE UPDATE

A Stone Age man is reconstructed, a prawn dating back millions of years is discovered, a tiny frog uses a carnivorous plant to survive, Earth bends space and an Atlantic mountain range is mapped.



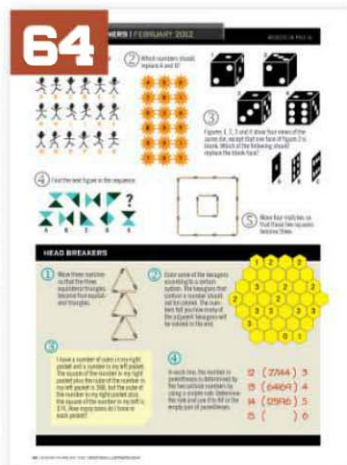
ASK US

How do birds reproduce? Can you generate gaseous iron? Why do large lakes seem to sing? Do green stars exist? Why are mummies brown? What is an arcminute?



BY THE NUMBERS

Get the stats on the world's most precious resource — water.



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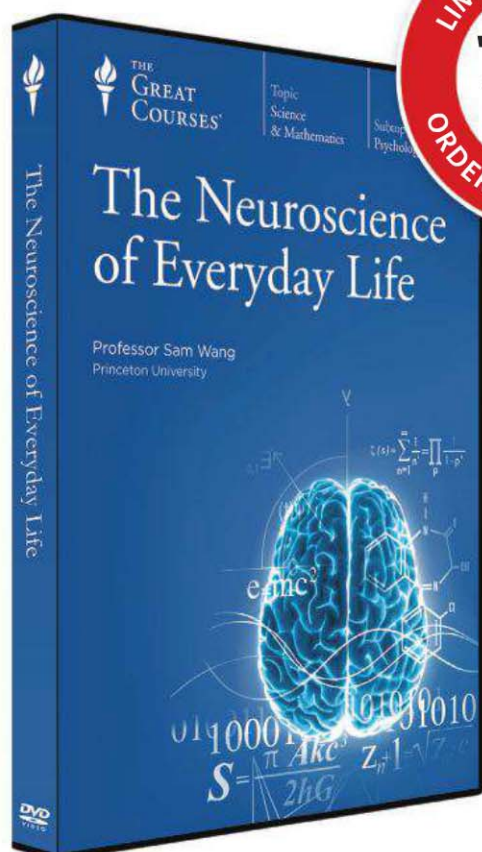
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8. Perception and Your Brain's Little Lies
9. Pain—All in Your Head?
10. Decisions—Your Brain's Secret Ballot
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13. Quirks of Memory
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Sailing Stones

I'm a retired consulting engineering geologist, and the story "Scientists Solve the Mystery of Sailing Desert Stones" [November/December 2011], which explains how rocks slide across Racetrack Playa in Death Valley, California, caught my interest. The author seems to suggest that this is a recent scientific finding, whereas we have known since at least 1976 that sheets of ice and meltwater buoy up the rocks, which permits strong winds to drive them across the playa. Authors R. P. Sharp and D. L. Carey describe the process in detail in the August 1996 issue of the journal *Geology*; they have studied this phenomenon since 1960 and should be credited. I saw and photographed the results myself immediately after a severe storm in February 1995, while camped at Racetrack Playa.

Chuck Winterhalder
Novato, California

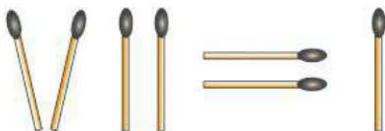
Bionic Man

The story on artificial limbs "Back On Their Feet" [November/December 2011] was quite interesting. I think it would have been appropriate to at least mention the pioneering work done on them by Professor Rajko Tomovic, beginning in Belgrade, Serbia, 40 years ago.

Eugene Kosso
Gualala, California

Another Solution

I enjoy your Bull's-Eye section as well as your challenging Brain Trainers and Head Breakers page. Speaking of the latter, there is an even better solution to Head Breakers No. 1 [November/December 2011] (shown below). Move two matches on the left to get $1 \times 1 = 1$, which



is an even better solution since the same number system is used. And, if inequalities are permitted, the two matches in the equal sign could be moved to form a greater than ($>$) sign. Indeed, a match on the left could be moved to the middle, and the upper one in the equal sign adjusted, to form the inequality $6 \geq 1$.

Dave Matson
Pasadena, California

EDITOR'S NOTE

Thanks, Dave; you weren't the only one who wrote in with alternate solutions to this particular problem. Our contributing mathematician, I. Martin Isaacs, responds:

Several readers suggested alternative solutions to the matchstick problem that appeared as Head Breaker No. 1. One idea was to create the equation $1 \times 1 = 1$, and that is an excellent solution. Another suggestion was to move one or two matches, thereby creating various inequalities. The problem, however, asked for a "true equation" and not simply a "true statement," so inequalities do not qualify.

LETTERS

Please send letters to the editor to letters@scienceillustrated.com. We regret that we cannot answer unpublished letters. Letters may be edited for length or clarity.

ON THE COVER

Russian space agency Roscosmos successfully launched a manned Soyuz rocket to the space station in mid-November, ensuring that it will remain occupied.

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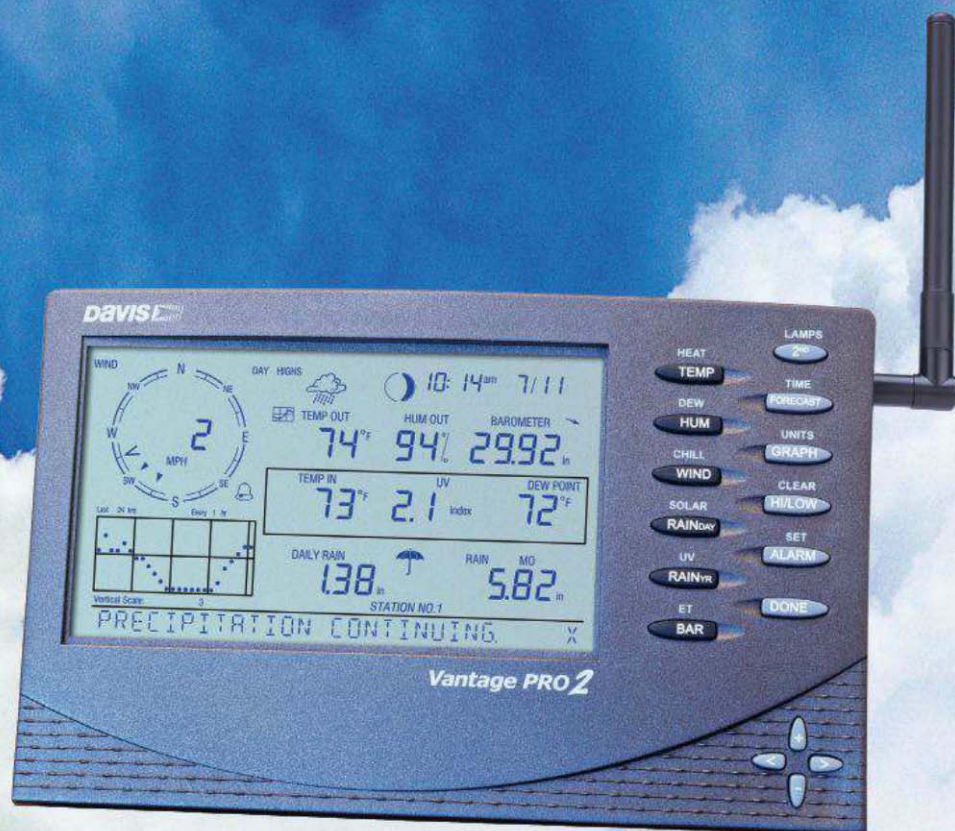


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AP PHOTO



INVISIBLE MAN

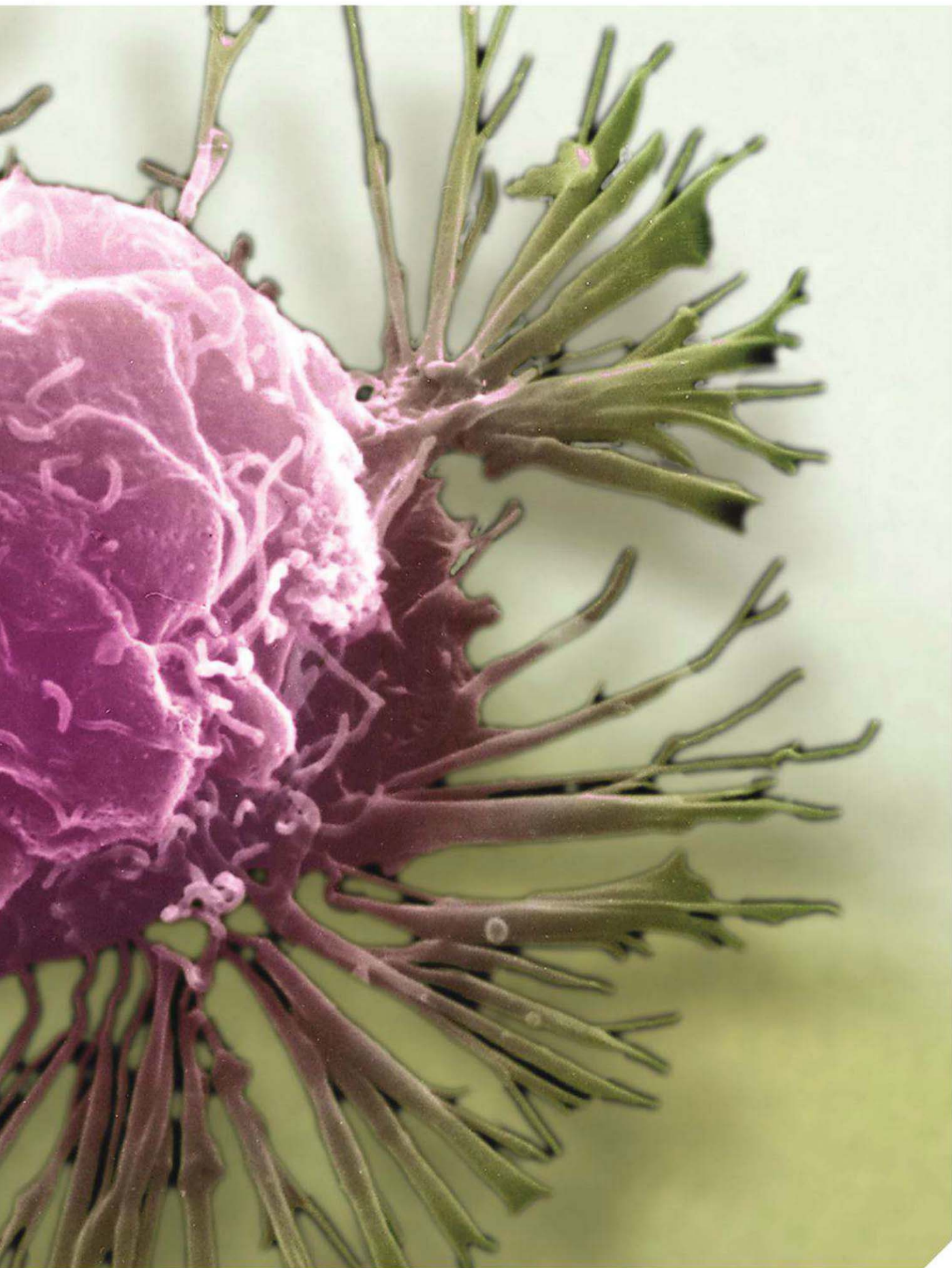
CHINESE ARTIST Liu Bolin is known for staging photo shoots in which he blends into the background so convincingly that passersby don't realize he's there. Here, he waits for the finishing touches for a piece entitled *Plasticizer* — a protest of the use of plasticizers in food additives.

BULL'S-EYE

- MEDICINE -

BREAST CANCER CELLS

THIS COLOR-ENHANCED scanning electron micrograph (SEM) shows a breast cancer cell's overall shape at a very high magnification. Cancer cells are best identified by internal characteristics; but a SEM can show how cells respond in changing environments and can map the distribution of the binding sites of hormones and other biological molecules.





BULL'S-EYE

- NATURE -

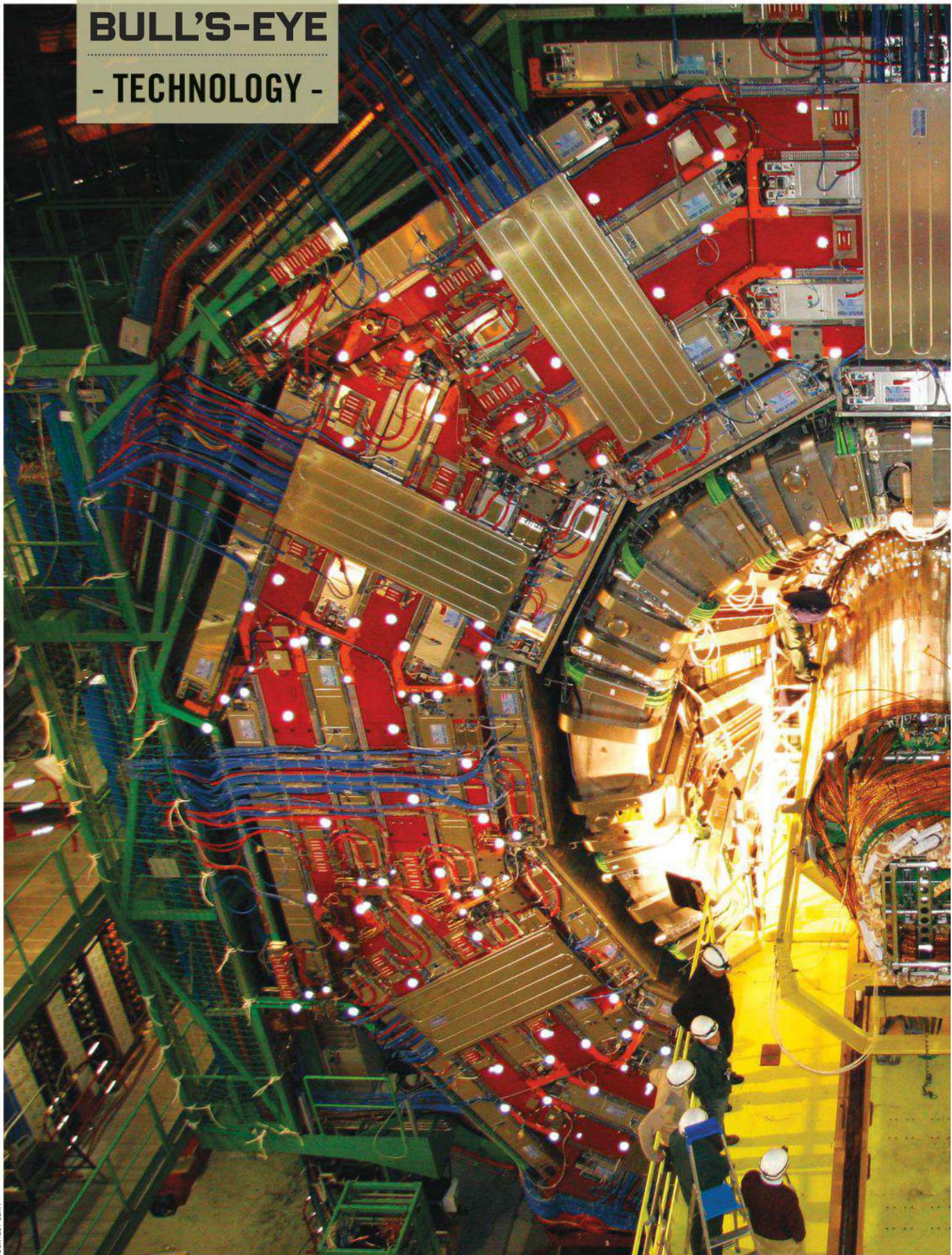
AN ICY PEEPHOLE

GLOBAL WARMING is usually blamed for melting glaciers and icebergs, and rightly so in many cases. But in the fjord off the Greenland town of Narsaq, and elsewhere on the island, a melting glacier is not an unusual sight. During the summer, rising temperatures polish and hollow out the giant frozen floats, often creating fantastic formations. This window to Narsaq thus does not necessarily forebode a flooded globe.



BULL'S-EYE

- TECHNOLOGY -



COURTESY CERN



DARK MATTER

HERE, A PART of the Compact Muon Solenoid (CMS) detector is shown in Cessy, France. CERN, the European Organization for Nuclear Research, uses it to study particle physics. The CMS experiment employs a general-purpose detector to investigate a wide range of physics, including the search for the Higgs boson, extra dimensions and particles that might make up dark matter.

Ötzi was a weather-beaten and muscular man.

ARCHAEOLOGY

ÖTZI

RECONSTRUCTED

Scientists re-create a Stone Age man.

He died 5,300 years ago, but now he's been reimagined. Named after the Ötztal Alps where he was found, Ötzi the Iceman is Europe's oldest natural human mummy. And now the mummy has been reconstructed more accurately than ever before, based on data obtained from CT scans, X-rays and DNA analyses. Ötzi died in a high mountain pass in Italy and was covered by ice. He was buried for millennia until two German hikers found him in 1991. Now two Dutch reconstruction experts, Adrie and Alfons Kennis, have reconstructed him based on examinations of the body and knowledge of what the faces, hands and skin of modern-day people who live mostly outdoors look like. DNA analyses revealed that Ötzi's eyes were not blue, as previously thought, but brown. Researchers determined his dark-brown hair color by examining preserved hairs found on his body.

Ötzi stood 5 feet 3 inches and was around 46 years old when he died after being wounded in the shoulder by an arrow. There are several theories about the circumstances of his death in the pass. One is that he was pursued by enemies and was shot with an arrow from behind, at which point he collapsed and bled to death. Another theory is that he was taken to the pass after his death to be buried. There is a stone platform 60 feet away from where the body was



PALEONTOLOGY



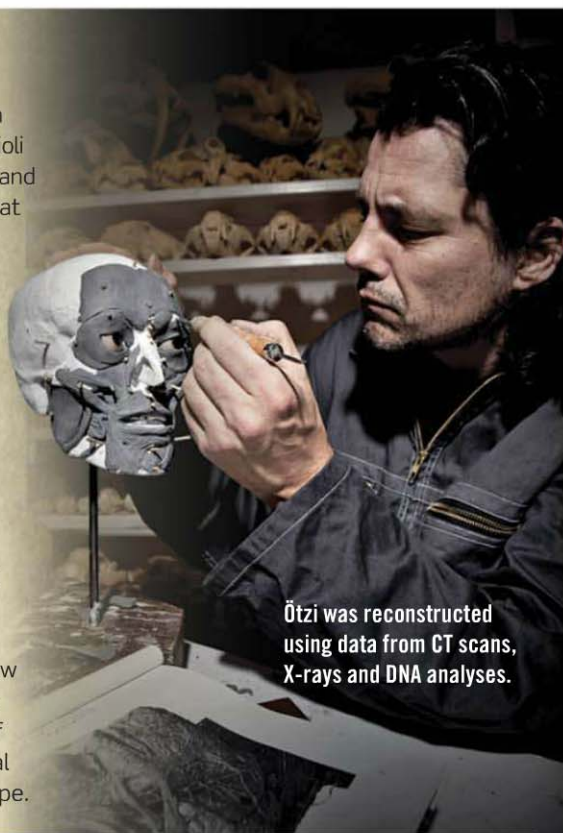
Prawns Much Older than Previously Thought

The discovery of a 360-million-year-old prawn in a rock in Oklahoma reveals that the creatures have existed at least 115 million years longer than previously thought. The 3-inch-long prawn was named *Aciculopoda mapesi* after paleontologist Royal Mapes, who found the fossil.

The prawn from Oklahoma is one of the oldest decapods — the order of 10-legged crustaceans that includes crabs and lobsters — ever discovered, and is very well preserved; the find may help map the evolution of decapods. The prawn lived in deep water with no strong current, which is why the tail musculature is so well preserved. The prawn was quickly buried in the seafloor, where the acidic water and low oxygen content also aided in muscle preservation.

The world's oldest prawn fossil is 360 million years old and was discovered in Oklahoma. The fossil looks much like a modern prawn.

found, which could have possibly been used for a burial ceremony. Luca Bondioli of the National Museum of Prehistory and Ethnography in Rome has proposed that warming and freezing cycles could have moved the body downhill from its original burial site. Proponents of this theory also think that if Ötzi was carried up to the pass from the lowlands for burial, he may have been an important, high-ranking member of his society. Since the circumstances of his death were violent, the reconstruction experts wanted to imbue the model with a haunted, insecure expression instead of portraying Ötzi as a competent, superior mountain wanderer. They also chose to portray Ötzi bare-chested to show how muscular he was, though in reality he was dressed for the harsh weather of the Alps when he died, wearing animal hide, a cap and an insulating grass cape.



Ötzi was reconstructed using data from CT scans, X-rays and DNA analyses.

BIG APES IN EUROPE STARVED

Dramatic climate change 9 million years ago caused Europe's big apes to die off, according to scientists from Claude Bernard University Lyon 1 in France. Grass replaced forests, which made it hard for the ancient relative of modern-day chimps and gorillas to find food. Evidence of the spread of grass can be seen in wear marks on the teeth of antelopes that lived at the same time as the big European apes.

NEW WEAPON AGAINST TOOTH DECAY

Scientists from the Dutch University of Groningen have decoded an enzyme causing tooth decay. The enzyme is present in bacteria that live in the mouth and digestive tract, which use it to convert the sugars from food into sticky chains that adhere to the teeth. This causes dental plaque buildup. The scientists say that it may be possible to add enzyme inhibitors to toothpaste, or possibly even to sweets.



The real Ötzi resides in a museum in South Tyrol, Italy. He is named after the Ötztal Alps.



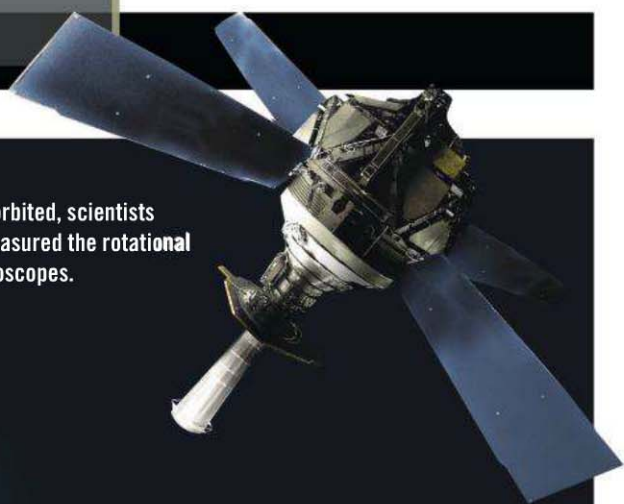
Two German hikers found Ötzi in 1991 in Italy near the Austrian border.

TECHNOLOGY

FLEXIBLE SOLAR CELLS SET A NEW RECORD

Swiss scientists have invented extremely energy-efficient solar cells, called flexible CIGS solar cells. With a thin polymer foil as their base, they are better suited for both portable electronics equipment and house facades than inflexible silicon solar cells. Moreover, their energy efficiency of 18.7 percent outperforms other flexible solar cells. Scientists hope that the flexible solar cells can be used to generate cheaper electricity in the future.





As the satellite orbited, scientists continuously measured the rotational axes of four gyroscopes.

ASTRONOMY

THE EARTH BENDS SPACE

After seven years in orbit, NASA's *Gravity Probe B* satellite confirmed two of the most important theories of how Earth's gravity and rotation affect space.

The measurements were made by observing the rotational axes of four ultraprecise gyroscopes inside the satellite. Each gyroscope consists of a tiny quartz ball, which is covered in a superconductive material and rotates 5,000 times per minute. The satellite telescope pointed at the IM Pegasi star in the Pegasus constellation, and because the direction was constant, magnetic quantum detectors could measure small changes in the gyroscopes' rotational axes. It was therefore possible to confirm the existence of two kinds of effects.

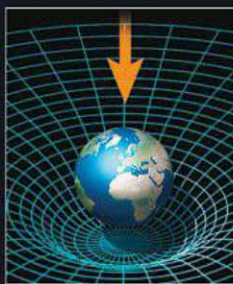
Albert Einstein described the first effect: The Earth's gravity

bends space — a phenomenon called the geodetic effect. Space can be seen as a kind of rubber membrane, in which Earth — and all other massive objects — causes a dent. Consequently, the rotational axes of the gyroscopes are displaced, and calculations estimate the displacement to be 0.0018 degrees each year. *Gravity Probe B* has now confirmed this within 0.3 percent accuracy.

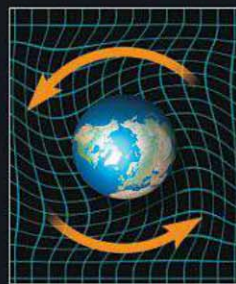
The other effect, predicted using Einstein's theories, was detected in 1918 by Austrian physicists Josef Lense and Hans Thirring. The Earth's rotation twists space; the twist has been calculated to be 0.000011 degrees annually. But because of technical problems with the satellite, this number has an uncertainty margin of 19 percent, a considerable increase over the expected 1 percent.

SATELLITE CONFIRMS TWO THEORIES

Gravity Probe B confirmed theories about two different effects that the Earth has on space.



1. The Earth's gravity bends space. Space can be compared to a rubber membrane, in which large objects such as the Earth cause a dent.



2. The Earth's rotation also twists space. It may be compared to a ball rotating in a jar of syrup; the ball's movement twists the syrup.

ZOOLOGY

TINY FROG LAYS EGGS IN CARNIVOROUS PLANT

In Borneo, biologists from Universiti Malaysia Sarawak have found a new frog species that is not much bigger than a pea. The maximum length of the frog, named *Microhyla nepenthicola*, is just half an inch, making it one of the tiniest in the world. The species may have evolved to be so small in order to lay eggs in a carnivorous pitcher plant (*Nepenthes ampullaria*) that traps and eats insects and other invertebrates. The plant dissolves its prey at the bottom of its liquid-filled pitcher, but tadpoles of the new frog species have adapted to grow up safely in the same liquid.

The frogs' small feet, which have less webbing than those of most frogs, may help them climb the pitcher's slippery interior.



The tiny frog uses the pitcher plant's liquid to hatch its eggs.



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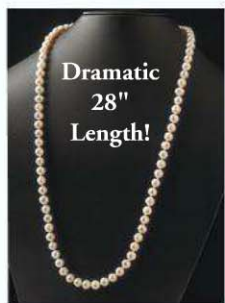
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MEDICINE

MOLECULE MAY PREVENT HEART DISEASE IN MODERATE DRINKERS

Several studies suggest that deaths due to heart disease and other cardiac problems occur 20 to 40 percent less often in moderate drinkers — those who consume one to three alcoholic drinks a day — than in nondrinkers. And scientists at the University of Rochester Medical Center may have discovered why.

The beneficial effect may be due to alcohol's effect on the Notch signaling molecule, which controls the quantity of smooth muscle cells in the artery walls. Excessive growth of these cells may entail thickening and narrowing of the arteries, which often causes heart attacks. The findings indicate that moderate quantities of alcohol block the Notch molecule's signal path, thereby limiting the growth of the smooth muscle cells.

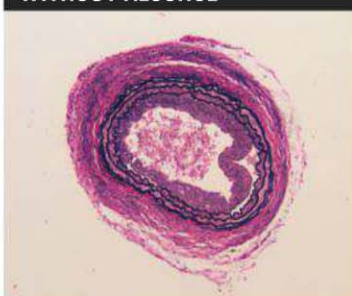
The effect was tested on the coronary arteries of humans and on the carotid arteries of mice. The scientists hope that the discovery will lead to the development of heart medicine possessing alcohol's beneficial qualities and none of its side effects.

The arteries were thinnest in the mice that had been treated with moderate alcohol.

WITH ALCOHOL



WITHOUT ALCOHOL



NICOTINE AND COCAINE HAVE THE SAME EFFECT

Cocaine and tobacco affect users in very different ways — but in the reward center of the brain, the two substances have a similar effect. According to a study conducted by the University of Chicago Medical Center, a single 15-minute first exposure to nicotine can trigger a memorylike response from dopamine — a neurotransmitter active in processing addictive drugs as well as natural rewards such as food. Researchers found that the brain records the effect of the nicotine and creates long-term changes in the brain, which make it difficult to quit.

A ship mapped out the submarine mountains using sonar technology.



GEOLOGY

ATLANTIC MOUNTAIN RANGE MAPPED

In the South Atlantic, some 1,200 miles southwest of Cape Town, South Africa, a team of scientists from the Scripps Institution of Oceanography and the University of California, San Diego, have mapped a deep-sea mountain range otherwise known only from satellite photos. The highest peak rises over 14,700 feet, making it slightly higher than Washington state's Mount Ranier.

The mountain range has flat-topped peaks and is extremely steep. Scientists are interested in these submarine mountain ranges,

which are also called seamounts, for several reasons. Closer examination of the seamounts' geological and chemical makeup can reveal a lot about the Earth's interior. Also, they have a profound effect on any given area's ecosystem.

The work of mapping out the world's submarine mountains has only just begun, however. So far, satellites have found 13,000 other underwater mountains, but according to the team, there are probably more than 100,000 submarine mountains throughout the world.

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TECHNOLOGY

NEW HEAT PUMP COULD LAST 10,000 YEARS

A traditional heat pump used to heat a house often must be replaced after 10 to 20 years of use. But now a team of Norwegian engineers has developed a new type of pump that they say will last for at least 10,000 years. The pump, which is about the size of a grain of raw sugar, is thermoelectric. Several thousand of the tiny pumps would be required to heat up an average-size home. The pumps may be assembled in a variety of shapes and sizes. Together, they cooperate to generate heat.

Scientists say that the tiny pump's long life is due to the fact that it only has one part, whereas a traditional pump consists of many parts, which introduces the potential for greater wear and tear. The new pumps only require the exchange of many fans that help spread heat through the building, and will likely be inexpensive to mass-produce because of the simplicity inherent in building just a single component. The researchers estimate that the pumps will be ready for sale within five to 10 years.

ZOOLOGY

PLASTIC IN A BLACK KITE'S NEST MAY SIGNAL STRENGTH

This predatory bird decorates its nest with pieces of white plastic.

Ornithologists at Consejo Superior de Investigaciones Científicas in Seville, Spain, have discovered that the black kite, a medium-size bird of prey, likes plastic. The strongest and most viable black kite couples collect white pieces of plastic to decorate their nests. The eye-catching ornaments show other birds that they command a large territory and are strong enough to protect it.

The ornithologists observed 127 kite nests in Doñana National Park in Spain and found that 77 percent of them were decorated. The male and female started the collection 20 days before egg-laying began. The ornamented nests primarily belonged to the strongest and most dominant birds ages 7 to 12 years old. Almost no ornamented nests appeared among very young or very old birds (up to 25 years). In an experiment in which the ornithologists placed plastic in the nests, most young and old birds got rid of the plastic pieces, while birds in the middle age group kept it.

The ornithologists concluded that the presence of white plastic in the nest indicates strength; if a nest is empty, its owner is vulnerable to other, stronger kites.

YOUNG BIRD



ADULT BIRD

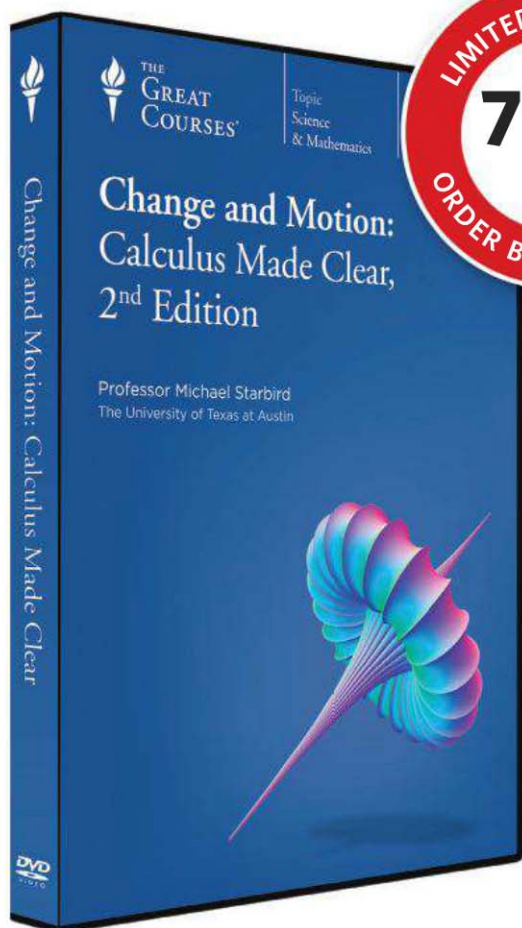


OLD BIRD



The strong kites in their prime years collect white plastic, whereas the young and old birds do not.

TOP LEFT: ELISABETH TONNESSEN/UNIVERSITETET I STAVANGER; FABRIZIO SERGIO (4)



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- FEBRUARY 2012 -

HOW DO BIRDS REPRODUCE?

I have often seen birds that seem to be kissing and wooing each other. How do they mate and produce offspring?

Birds have some of the most sophisticated courting and mating rituals in the animal kingdom. They perform songs and dances and are subjected to tests, all of which give the females and males a chance to assess each other's qualities and strengthen their bond. Once the courtship is over, if the female has accepted the male as a mate, then the mating and fertilization take place. Males, however, are sterile outside the mating season.

All bird species have internal fertilization; the male transmits its sperm cells directly to the female's genital opening, allowing them to reach and fertilize her mature eggs inside her ovaries. From there, the sperm is carried through the oviduct, where it sometimes



Only a few birds, such as this Argentine lake duck, have a penislike attachment that is used for mating.

stays for several weeks in a special chamber before it is needed for fertilization in the ovary. Once the eggs have been fertilized, they are carried out of the oviduct system while the embryo develops. In the womb, the embryo is equipped with a protective calcium shell, and shortly after, the egg is laid.

Internal fertilization is performed by all animals that give live birth or lay eggs with a protective shell surrounding the embryo. The process is necessary for all terrestrial animals whose fertilization does not take place in water.

CAN YOU GENERATE GASEOUS IRON?



When iron is heated to 5,182 degrees F, it will boil and thereby change into a gaseous state.

All substances have four different states — solid, liquid, gas and plasma — and they change from one state to another when heated. The final state is plasma, in which the atoms of the substance lose the outermost electrons, so that the substance consists of positive ions and negative electrons. In stars, including the sun, all substances — including iron — are in the plasma state.

On Earth, iron is a solid metal. If heated to 2,800 degrees F, it will melt, and at 5,182 degrees F, it will boil. So, to generate gaseous iron, you must heat it to at least this temperature. If further heated, the iron vapor will gradually become plasma, but even at the sun's surface temperature of 9,941 degrees F, the iron atoms have only lost the outermost of their 26 electrons. In the even hotter corona, where the temperature reaches 27 million degrees, most iron atoms have only lost between six and eight electrons. There are exoplanets that are so hot that they could, in theory, harbor lakes of liquid iron.

CLOCKWISE FROM TOP: LEFT: PATRICIA BRENNAN; MASTERFILE/SCANPIX & CLAUDE LUNAU (ILLUSTRATION); SPL/SCANPIX; PHOTO/TO/SCANPIX

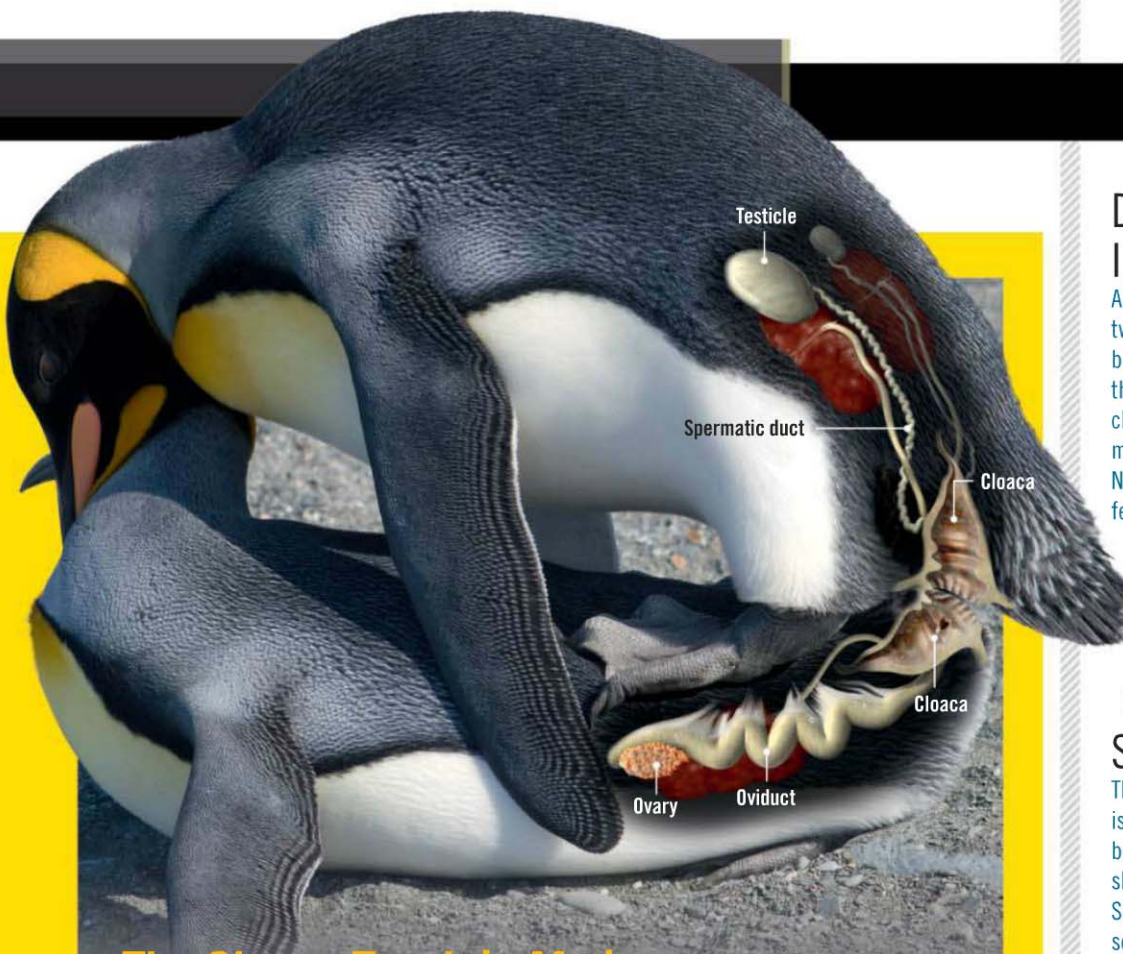
IN SHORT

DO TWINS HAVE IDENTICAL DNA?

Almost universally, identical twins have identical genes, but in a few rare instances, the genetic material can change slightly after the mother's egg has split in two. Nonidentical twins have different DNA, just like siblings who are not twins.

WHICH BREED OF DOG IS THE SMARTEST?

The most intelligent dog breed is the border collie, originally bred to help shepherds herd sheep. It is named after the Scottish Borders district in southern Scotland.



The Cloaca Touch in Mating

Birds do not have a separate genital opening; they have a chamber called a cloaca with a large external opening, where the rectum and urethra also end. This means that the cloaca is important for mating as well as getting rid of waste.

The mating takes place when the male forces its cloaca against the female's, so that the male's sperm cells can be transferred. In a few bird species, such as ostriches and some ducks, the males have a penislike appendage, which enters the female's genital opening during mating.

Why Does the Ice of Large Lakes Seem to Sing?

Ice "sings" when small cracks originate in one place and spread quickly across a large lake, causing the ice to vibrate; lakes smaller than 100,000 square feet aren't big enough to create a network of cracks.

As the cracks in the ice spread, listeners may be able to hear that the sound starts in one place and moves fast. When the vibrations are carried into the air, it sounds as if the ice is singing — a bit like standing near a railroad as a train approaches.

The cracks that produce the singing originate for several reasons; common among them is tension,

which builds up in the ice and causes it to crack. Movement of the Earth's tectonic plates similarly builds up tension in the crust, which is sometimes released in an earthquake.

The cause of the tension may be atmospheric pressure changes; the ice must follow suit, and because the ice is stiff, it adjusts by cracking. The cracks can also be caused by considerable air temperature variation. Cold ice takes up less space than warmer ice, so falling temperatures make the ice contract and crack. In very large lakes, there may also be enough of a tide to cause the formation of cracks.



The ice sings because of changing pressure, changing temperatures and changing tides.

The sun is a green star, though it seems white because it emits light of many colors.

WHAT IS AN ARCMINUTE?

The distance from the Earth's pole to the equator is divided into 90 degrees of latitude. Each of those degrees is divided into 60 arcminutes. The length of an arcminute is the distance from the pole to the equator: 6,214 miles, divided by 90×60 , or 1.15 miles/1 nautical mile.

DO GREEN STARS EXIST?

Stars with a temperature of 7,200 to 12,600 degrees F emit the major part of their light in the visible spectrum. For each temperature, there is a specific wavelength in which most of the light is emitted. The wavelengths of green light are 500 to 560 nm, meaning that stars with temperatures between 9,400 and 10,475 degrees emit most of the light in the green area. This type of star is very common. The sun

belongs to this group, even though we do not perceive it as a green star.

The sun seems white to us because it does not just emit light within one particular wavelength. If most of the light emitted is in the green area, there is also a lot of light emitted in the other colors of the spectrum. When the eye perceives light from so many colors, it sees a mixture of all colors, which it perceives as white.

WHY IS THE BOTTOM OF A BOTTLE CURVED UPWARD?

Originally, glass blowers made the inward bulge at the bottom of bottles to have the bottle enclose its own "navel." The navel was the place where the bottle was fastened to the glass blower's pipe, and once the pipe was removed, it left an uneven projection that could scratch the surface it sat on. Also, the inward bulge makes the bottle stronger.

Why Are Mummies Brown?

The common brown color of mummies is caused by the body's natural iron content. When embalmed, the weight of the body is reduced by more than 70 percent, but only liquid disappears, and thus different bodily minerals are greatly concentrated and seen more clearly.

The Greek historian Herodotus described the embalment process step by step, but scientists still had unanswered questions, so in 1994, Long Island University professor Bob Brier

performed an embalment using ancient Egyptian methods to make a modern mummy, which answered some of the questions. For many years, scientists thought that the dark color was due to resin treatment and the long stay in the tomb. But Bob Brier's mummy turned dark brown after only 35 days of dehydration, leading scientists to conclude that the change of color occurred in tandem with the falling body weight and was caused by a high concentration of iron.



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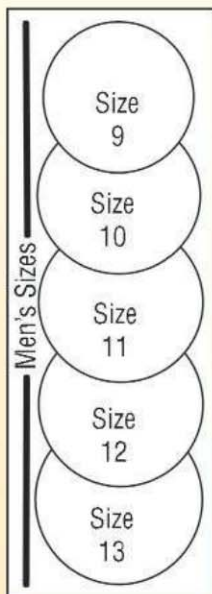
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THE DREAM OF MARS

Mars has always fascinated people, but only in recent decades has the idea of visiting the planet become realistic. This is the third installment in a three-story series examining the effort to reach Mars and potential colonization of the red planet.

PREPARATION

Patient astronauts break ground on Earth.

MICHAEL DALGAARD



EXPLORATION

Probes will increase our understanding of the planet.

NASA



CONQUEST

Will humans establish an extra-terrestrial base on Mars?

HENNING DALHOFF



ILLUSTRATION: HENNING DALHOFF (SPR), SCANDIX (TOP LEFT)

A close-up photograph of a robotic hand, likely from the Mars Science Laboratory's Curiosity rover, holding a large, reddish-brown brick. The hand is made of a dark, textured material with lighter-colored joints. The background is a hazy, orange-tinted Martian landscape. The overall image conveys the theme of building a permanent base on Mars.

Perhaps the first building on Mars will be made of brick, given that bricks could be manufactured relatively easily there.

A NEW ERA

Setting up a permanent base on Mars may no longer be a distant dream. Plans already exist; only funding is needed for implementation.



TRAVELING TO MARS

People may be able to reach Mars in one of many ways. In connection with the Constellation Program, NASA prepared one detailed plan, Constellation, which was cancelled by President Obama in 2010. However, the plan, whose basic steps are outlined below, could be revived during a more favorable economic period.

1. The first spacecraft will be launched into orbit around Mars. The craft will be used for the return to Earth and will be loaded with fuel and food supplies for the astronauts' return journey.

2. Spacecraft No. 2, called *Cargo-1*, will deliver materials such as exploration vehicles, plants and foodstuff. It will also contain the surface power system, most likely a small nuclear reactor.

3. The third spacecraft will be a residential module laden with plenty of supplies and a scientific lab. This spacecraft will be the astronauts' primary base once they arrive. The craft will land near *Cargo-1* and will also hold an additional nuclear reactor.

4. Two years after the second and third crafts are sent, a fourth piloted craft, containing six astronauts and a second surface habitat, will follow. After 500 days on Mars, the astronauts will get in the return spacecraft and head home.

1

4

3

2

ILLUSTRATIONS BY HENNING DALHOFF
SPACEX/AMPA (TOP LEFT), ARCHIVE (OPPOSITE, TOP RIGHT)

In 1951, the now famous author Arthur C. Clarke wrote a slim novel entitled *The Sands of Mars*. It was one of the first attempts to describe the colonization of our neighboring planet, and there is little doubt that the novel inspired many of the scientists who have subsequently devoted time to researching Mars. Clarke's science fiction, imagining domed cities in which people could walk about freely, just as on Earth, made the idea of colonizing Mars very appealing. There were red deserts and plants. The temperature was so high and the air so dense that it was possible to go outside wearing only Mars-appropriate clothing and an oxygen mask.

Real Mars explorers will almost certainly never have such an experience. Even though research indicates that Mars is much less similar to Earth than we once thought, that has not curbed interest in building bases and colonies. Recent research has also revealed both good and bad news when it comes to the chance of establishing a permanent settlement. Promisingly, there appear to be large quantities of ice right beneath the surface in many places on Mars. Easy access to water would certainly make it less complicated to establish a base. Unfortunately, the atmosphere is very thin, with a pressure similar to that found 18.6 miles above the Earth. And there is



The barren polar desert landscape of Devon Island in northern Canada is a lot like Mars. Consequently, a small trial base has been established here.

no ozone layer protecting against ultraviolet radiation from the sun, which means that it would always be necessary to wear a space suit when going outside.

Another issue hindering Mars exploration is the difficulty of landing. The thin, erratic atmosphere is able to slow down probes weighing up to a couple of tons, and those can descend by parachute. But this would be impossible with a 30- to 60-ton spacecraft, which is the expected weight of payloads carrying all the necessary survival supplies for a manned mission on the planet. The last phase of the landing would have to be facilitated by braking rockets, which would require fuel to be carried millions of miles from Earth. This presents such a problem that it's forcing scientists to consider the possibility of producing fuel on Mars for the return trip.

COSMIC CAMPING

The residential module will be compact and will only contain what is absolutely necessary for exploring and living on Mars.

EMERGENCY ROOM

One of the astronauts will be a doctor, and simple surgery could be performed.

AIR LOCK

The surface will be accessed through an air lock. On the way in, suits will be blown clear of the fine Martian dust.

LABORATORY

In order to prevent pollution, samples will be examined in airtight containers.

GROUND FLOOR

KITCHEN

It will not be possible to cook in the module, so the kitchen will only be used for heating up convenience food.

BATHROOM

The sparse water resources will have to be reused. The water will be cleaned of dirt and bacteria regularly.

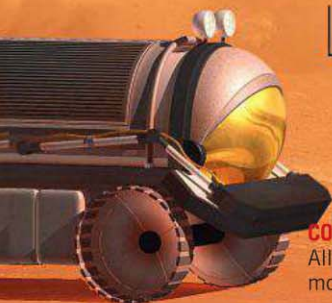
FIRST FLOOR

LIVING ROOM

The astronauts will relax with books and films. They will sleep on the second floor in small individual cabins.

CONTROL CENTER

All systems will be monitored on large screens.





We will go in 2036 at the earliest. Not because of technological difficulties, but for political reasons. The most likely scenario is that a manned mission will be launched 2040 to 2050.



— Vadim Rygalov, University of North Dakota biophysicist and expert on life-supporting systems

ESTABLISHING A BASE

Most manned missions plan for 500 days spent on the planet, but it's possible that astronauts would begin establishing a permanent base in connection with the first landing. Because of the enormous distance and long travel time, it would be necessary to consider

staying on Mars for many months, perhaps even for several years. The first base will most likely be modest, and will encounter obstacles large and small, from dust invading everything to cosmic radiation.

The first base would also most likely be prefabricated. It would be built on Earth and sent to Mars onboard an unmanned spacecraft, which would limit its size. A good estimate is a cylinder with a 26-foot diameter and a height of 36 feet, as envisioned by the Mars Society, which is led by engineer Robert Zubrin. For years, the organization has tried to prepare for man's trip to Mars, including by building models of bases in Arctic Canada.

the spot, which will be necessary since it will not be possible to bring much back to Earth. Scientists will rely heavily on an electron microscope, which can look for microorganisms, and an X-ray spectrometer, which can be used to determine the mineral makeup. A gas chromatograph can be utilized to examine the samples' organic substance content.

From the ground floor, the astronauts will be able to access the surface by passing through two air locks; between the two locks will be a repair shop. On the first floor will be the living room, kitchen, bathroom, a storm cell and an exercise room. Exercise will be crucial, because the gravity of Mars is roughly one-third of the Earth's. In order to keep their bones and muscles fit, astronauts will have to exercise for one to two hours a day. The storm cell will be necessary in case of solar eruptions, which entail dangerously high radiation levels and occur because Mars has a very thin atmosphere and no magnetic field whatsoever.

Though the base will of course be designed to be as comfortable as possible, astronauts will spend quite a lot of time outside the base doing research. A large part of their job will consist of driving around in large "tractors," complete with pressure cabins and air locks, allowing them to leave the vehicle and do fieldwork. Some of these expeditions may last several weeks and take them up to 310 miles away from the base.

PLANTS AND FUEL

The two main tasks of the first base will be the production of food and rocket fuel. Plants will be

The first visit to Mars' surface will probably last 30 days. Spending 30 days on Mars, we could fly back to Earth in the same window and make the return in 200 days.



— Brian Harvey, Irish writer and space expert

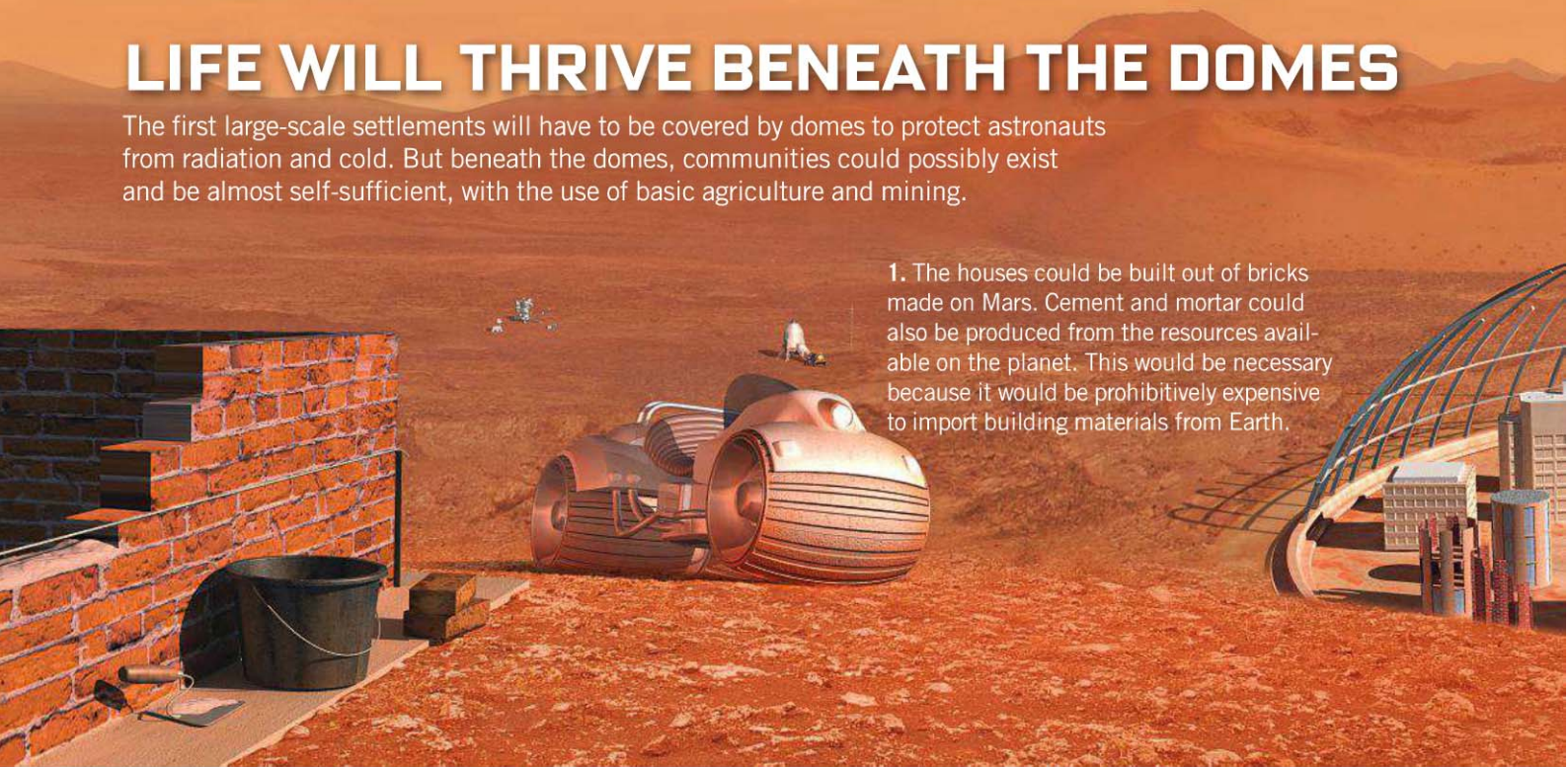
THIRD TIME'S A CHARM

The society is now designing its third and most sophisticated model, the three-story Euro-MARS, meant to house six astronauts for almost two years. On the ground floor will be scientific labs for the analysis of most samples on

LIFE WILL THRIVE BENEATH THE DOMES

The first large-scale settlements will have to be covered by domes to protect astronauts from radiation and cold. But beneath the domes, communities could possibly exist and be almost self-sufficient, with the use of basic agriculture and mining.

1. The houses could be built out of bricks made on Mars. Cement and mortar could also be produced from the resources available on the planet. This would be necessary because it would be prohibitively expensive to import building materials from Earth.



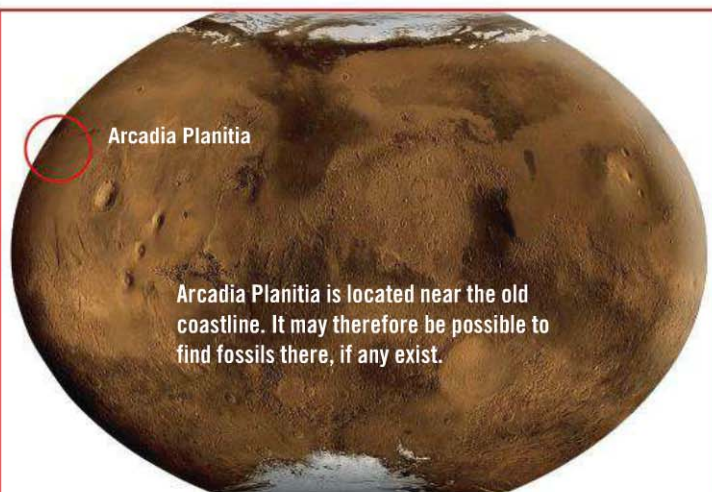
grown in greenhouses, which presents the unique challenge of maintaining a terrestrial environment and climate on Mars. One idea has been to create genetically modified plants, which could be altered to cope with ultraviolet radiation and low temperatures and survive on very little water.

The second vital task for the astronauts will be the production of fuel. They will use the Sabatier process, which involves a simple reaction between hydrogen imported from Earth and CO_2 from Mars' atmosphere. In the process, hydrogen and CO_2 are converted into methane and water. The water produced can then be separated into oxygen and hydrogen by electrolysis; the hydrogen can be reused in the process, while the oxygen can be utilized to burn methane in the rocket engine.

The operation will require a lot of energy, so a small nuclear power station will have to be built rather quickly close to the base, likely being carried to the planet aboard one of the early spacecraft.

THE DREAM OF COLONIZATION

In the short term, man's presence on Mars will most likely resemble the Amundsen-Scott South Pole Station. But the dream of colonizing Mars remains strong, and as space operations gradually become less expensive, the emergence of a real colony is not impossible. It would mean establishing something possibly like the domed cities described by Clarke in his 1951 novel, and it would present an entirely new set of challenges. A modest greenhouse and small plants would no longer be enough; a closed biosphere would be necessary, including



Arcadia Planitia

Arcadia Planitia is located near the old coastline. It may therefore be possible to find fossils there, if any exist.

ASTRONAUTS WILL BE NEITHER COLD NOR THIRSTY

When it's decided where the first base will be located, there will be a necessary compromise between access to ice — and thus water — and reasonable climatic conditions. Near the poles, there is a lot of ice, but temperatures hovering around -200 degrees Fahrenheit are too cold for human habitation.

It is possible, however, to find ice below the surface closer to the equator. For instance, the *Mars Reconnaissance Orbiter* space probe discovered meteor craters in 2008 in the area called Arcadia Planitia at around 47 degrees north latitude (where Paris is on Earth). The craters were only a few feet deep, and in several of them the strikes had exposed ice all the way to the surface. The ice quickly evaporated because of the low atmospheric pressure, but in the future, astronauts might be able to utilize it.

2. A cluster of brick houses could be built before a giant dome shields the complex, protecting the inhabitants from the hazardous radiation. The temperature could be kept at a consistent level.

3. Over time, there would probably be more domed cities, each of which could specialize in something, such as agriculture. Domed cities could be connected by small shuttles.



It is very important that we do not repeat the *Apollo* pattern and spend time planting flags and making footprints. Instead, we must build an infrastructure in space that can support future expeditions.



— Mark Nelson, participant, Biosphere 2, Arizona, 1991-93

both plants and animals, so as not to have to import food from Earth.

Another issue would be the transportation costs of building materials, though it's not impossible that most could be created on the planet. In the 1980s, scientists realized that it

would actually be quite easy to manufacture bricks on Mars. According to engineer Bruce MacKenzie of the Mars Homestead Project, the best material for building the first city on Mars is brick, which can be made by simply taking some surface dust, adding water, and then squeezing, drying and baking it. It is also possible to produce mortar and cement, so the first buildings on Mars could very well be neat redbrick houses.

However, the low temperatures and the radiation from space present special challenges. One solution could be to build the houses in ditches and subsequently cover them with cement. Or, builders could construct a dome over the entire settlement, which could be built in the shape of a square. Under the dome, there could be green plants and perhaps an artificial lake as well.

Living beneath such a dome would, however, come at a price. The gravity on Mars is only 38 percent as strong as the gravity on Earth, and children born and raised on the planet might not be able to travel to Earth, because of their muscles and bones' adaptation to the weak gravity. Even settlers who had gone to Mars as adults would probably face great difficulties if they wanted to visit Earth again.

TERRAFORMING MARS

In the foreseeable future, a Mars colony could at most support a few thousand people, but if it were possible to terraform the planet, it could, in theory, support a much larger population. Terraforming — changing the temperature and atmosphere of a planet enough to enable humans to live unconstrained on its surface — is possible in theory. Scientists know that Mars was once very similar to the Earth. According to geologists, there may have been a large ocean in the Northern Hemisphere some 3 billion years ago, just as there were rivers and active volcanoes. At that time, Mars was both warmer and more humid. But re-creating this scenario would be a project that would demand patience over the course of many generations. Even in the most favorable conditions, it would take several thousand years to convert the red planet to a blue and green globe resembling the Earth.

Nevertheless, scientists have already begun to consider how to undertake such a spectacular project. The first person to present the idea was Carl Sagan, who suggested terraforming Venus in 1961. In the following years, Sagan came to play a central role in the exploration of the solar system, and in 1973 he described how it would be possible to terraform Mars. Since then, the idea has been taken up by several other scientists, the most well known of whom is James Lovelock, a scientist and environmentalist who first proposed the Gaia hypothesis about the Earth as a self-regulating superorganism. In 1984, he and Michael Allaby wrote *The Greening of Mars*, in which they first described the possibility of using chlorofluorocarbon (CFC) gases to create an extensive global warming effect.

EARTH VERSION 2.0

Terraforming Mars would take thousands of years. But, in theory, it could be done. And once water and plants had been introduced, it's possible that human beings could move around unrestricted.

Terraforming Mars would require a temperature increase through the use of CFC gases or giant orbiting mirrors or the importation of dark sediment.

Raising the planet's temperature would be the first step in successfully terraforming it. There are three possibilities — first, as Lovelock suggested, by enriching the atmosphere with powerful CFC gases that are much more efficient at warming than the CO₂ that is already present. The second possibility would be to increase solar radiation by placing giant mirrors in orbit around the planet. Finally, fine dust, perhaps from the two small moons Phobos and Deimos, could be spread over the polar caps, allowing Mars to absorb sunlight more efficiently.

ADDING MELTED ICE TO THE ATMOSPHERE

If the polar caps were melted on purpose, then the billions of tons of ice and snow found there could contribute to the atmospheric density and thus to global warming. But if scientists hope to generate a seriously denser atmosphere, it may also be necessary to include the ice found below the surface, which melts once it is brought into contact with the air.

Bringing the ice into the open would probably require using powerful explosives or perhaps bombarding Mars with giant rocks and meteors, which could crack the surface open.

But even after hundreds of years of endeavors, the atmosphere would still be cold, thin and almost devoid of oxygen. Consequently, biologists would take over for the next few steps, introducing a robust fauna. At first it could be customized moss and lichen, followed by pine trees. The plants would generate fertile topsoil and convert atmospheric CO₂ into oxygen. Later, scientists hypothesize, genetically modified animals that could survive in the tough climate could follow.

The last step in colonization would be to leave the domed cities and occupy the entire planet, though this is not on the horizon in the foreseeable future. Only with the investment of significant time, energy and financial resources might science one day transform the red planet. **SCI**

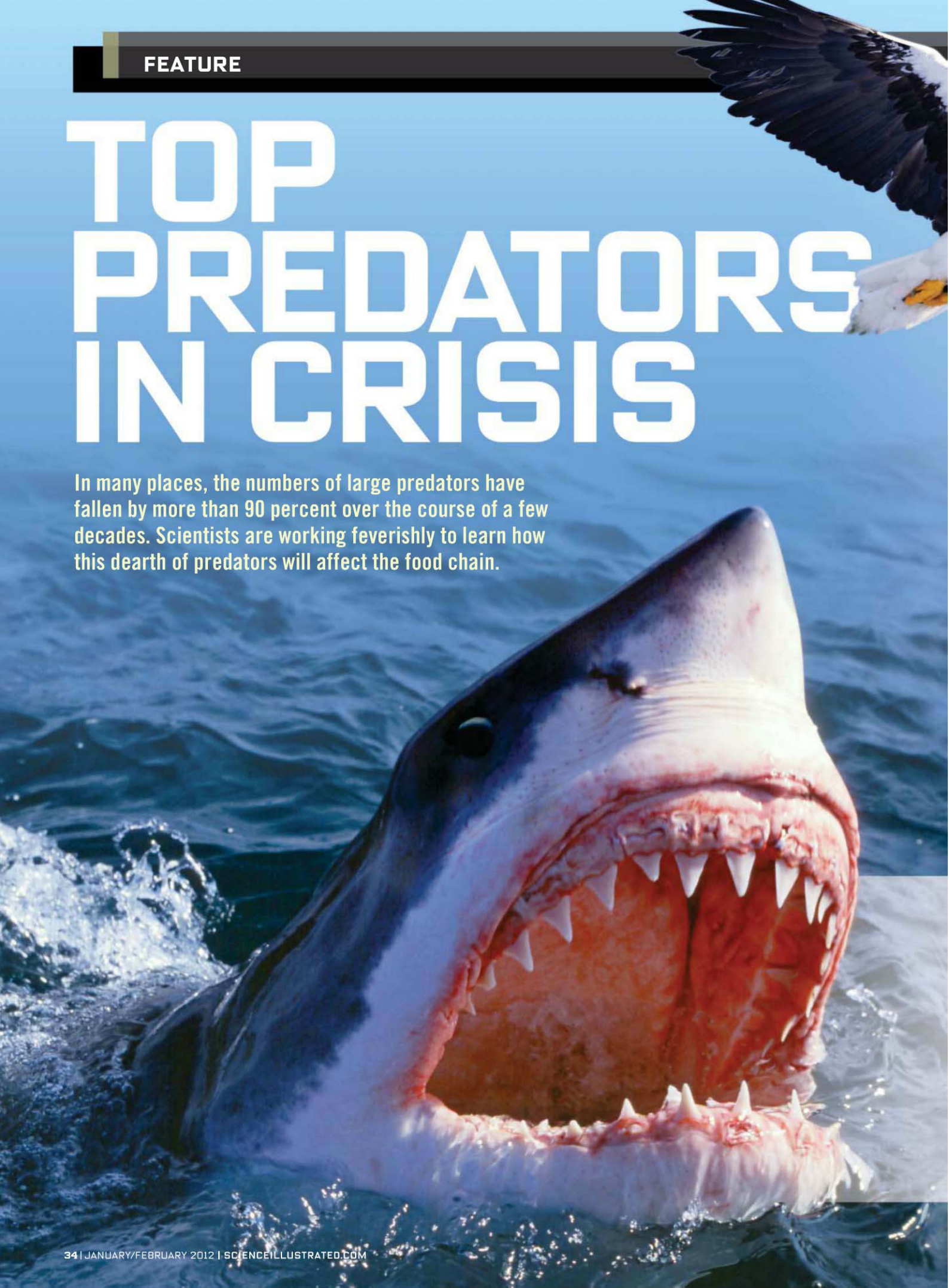
During the second expedition, we would establish agriculture to be utilized by future travelers. Indigestible biomass and human waste would be composted and used as the basis for developing organic material to be incorporated in agriculture. Rice would be the main crop.

— Masamichi Yamashita, professor, Japanese Institute of Space and Astronautical Science



TOP PREDATORS IN CRISIS

In many places, the numbers of large predators have fallen by more than 90 percent over the course of a few decades. Scientists are working feverishly to learn how this dearth of predators will affect the food chain.





Humans have a long history of usurping the habitats of large predators, in addition to overhunting and overfishing them. Lion populations alone have fallen from around 400,000 to just 20,000 worldwide since the 1940s. Some populations of sharks have fallen by 90 percent in the last few decades, and similarly alarming trends can be seen in populations of other large predators, including eagles. In most of Western Europe and the United States, the brown bear has long since disappeared; in the forests of Asia, there are only small, isolated populations of tigers. In some places, top predators have become so scarce that they have affected whole ecosystems and are threatening to alter food chains, changing the ecological order on land, at sea and in the air.

Large predators such as sharks, eagles and lions have all seen their numbers decline. The disappearance of top predators may have serious consequences.

NATURE PLS (3)



ABSENCE OF WOLVES AFFECTS MANY ANIMALS IN THE FOOD CHAIN

Since 1995, Yellowstone National Park has been a living laboratory for biologists. Wolves had long been exterminated in the park, but after their reintroduction, scientists have been able to reconstruct how the food chain is affected when the wolf is under pressure.



REINTRODUCING PREDATORS

Current research is complicated by the fact that the present doesn't tell the whole story about the effects of the declining numbers of predators. In many places, the loss of top predators started long before modern ecological theories and methods were introduced between 50 and 60 years ago, which makes comparing ecosystems with and without predators difficult. Biologists can, however, study the importance of top predators by observing ecosystems in areas where the animals have been reintroduced after they had long been absent. Yellowstone National Park has been a living laboratory ever since the first wolves were reintroduced in 1995; they were completely wiped out in the area in the 1920s and had been absent from it ever since.

Before the wolf reintroduction, aspen, cottonwood and willow trees in many parts of Yellowstone were severely damaged because an army of herbivores, such as elk, were eating them. Red deer damaged the park's trees so much that the beavers of Yellowstone and

elsewhere in the Rocky Mountains lost the building blocks for dam construction, leading to a local beaver extinction. Beavers are the most efficient landscape architects among animals, so as beaver populations dwindled, innumerable small and large wetlands behind their dams disappeared. These wetlands used to provide the landscape with a wealth of biodiversity.

MORE WOLVES MEANS MORE TREES

Just a few years after the reintroduction of wolves in Yellowstone, the first ecological effects of their presence emerged. Elk numbers fell, and the elk still living in the area became more cautious. Before the reintroduction of wolves, the animals ate the trees everywhere, but afterward, they began to avoid steep mountainsides, flooded forests and brush where there was plenty of food but escape would have been difficult. And even when the elk graze in flat landscapes where it is easier to escape from predators, they spend a lot of time with their heads high, looking for wolves.

This increased attentiveness may mean the difference between life and death for the elk, but it also limits the time that they can spend grazing — to the benefit of trees, beavers and small birds that nest in the trees.

WOLVES HAVE A FAR-REACHING EFFECT

The wolves' presence has affected not only elk, beavers, small birds and trees, but also the local scavengers. Ravens, eagles and coyotes get a welcome dietary supplement in the form of carcasses left by wolves, which helps them survive the cold Wyoming winters. Without wolves, the availability of winter carcasses is more unpredictable, since during mild winters only a few deer die from lack of food. And since climatologists expect mild winters to increase as a result of global warming, scavengers without access to the carrion provided by wolves may suffer. In wolf-rich areas, scavengers could be supplied with carcasses all year. Thus, the wolves may help scavengers adapt to changing times.

Although coyotes also benefit from carcasses left behind by wolves, the increasing wolf population in Yellowstone has caused a shift in the smaller coyote population. Today, the number of coyotes in the park has declined, and in the core wolf areas, there is, on average, one-third

of the density of coyotes compared to other areas of the park. The wolf considers its smaller cousin a competitor that must be killed; thus, coyotes have moved their dens to wolf-free areas of the park. The coyotes are especially in danger during the mating season, because the wolves can easily track a female coyote's burrow and cubs. And because coyotes hunt smaller prey than wolves, the numbers of smaller prey often increase when wolves take over from coyotes.

Removing an animal, such as a coyote or wolf, from its habitat can have other unpredictable consequences as well. Coyotes help control numbers of both domestic and feral cats, which kill native birds. Removing coyotes from urban areas such as Los Angeles or Chicago could affect local avian populations. In western Texas, the extermination of coyotes had completely different consequences. When the coyotes were removed from a research area with

scattered bushes and grass, an open war over food broke out among the 12 rodent species of the area. Eventually, only a single rodent species, the kangaroo rat, remained.

PROBLEMS AT SEA

The lack of predators affects marine animals as well. In recent decades, biologists have recorded a marked growth of small predator fish when the populations of large predator fish collapse because of overfishing. However, biologists are not always certain how far down the ocean food chain the ecological effect reverberates. In parts of the Baltic Sea, declining numbers of the dominant predator fish, such as pike and perch, create ripples throughout the ecosystem and cause certain algae to bloom. This happens because the lack of predator fish allows for the nearly unlimited growth of small fish, such as sticklebacks. Once there are more sticklebacks, there will be a

PREDATORS PROTECT ENDANGERED AUSTRALIAN ANIMALS

In the past 200 years, nearly half of the mammal species that have gone extinct have been in Australia. At least 29 species have disappeared from mainland Australia, 19 of which are now completely extinct. Most affected are rodents and marsupials. Many of the problems are caused by two foreign predators — the fox and the domestic cat. These two medium-size predators have no natural enemies because Australia's top predators, the Tasmanian devil, marsupial lion and thylacine, or Tasmanian tiger, have been extinct in mainland Australia for at least 4,000 years. The dingo has to some extent taken over the predator's ecological niche, and, today, it is a four-legged security guard against foxes and domestic cats in many places. In areas with dingoes, the natives,



Bilby



Dusky hopping mouse

such as the highly endangered bilby and the dusky hopping mouse, fare much better than in areas without dingoes. Another rare animal, the rufous hare wallaby, was not so lucky, as foxes have exterminated the last mainland population.

Though the dingo (right) also eats local bilbies and mice, it has lower reproduction rates than foxes and domesticated cats, which may help the local mammals survive.





The steller's sea eagle is one of the world's largest raptors, with a wingspan of over 6 feet. Like many other top raptors, the steller's sea eagle is vulnerable to extinction.

tremendous decline of stickleback prey, including small crustaceans. In turn, these crustaceans live off algae and normally keep the algae populations under control, but when they disappear, the algae bloom.

In the Black Sea, the absence of top predators has had even more serious consequences for the ecosystem. Overfishing of dolphins and large predator fish in the 1970s meant a massive increase of small, crustacean-consuming fish species. Fewer crustaceans to eat algae created large algae blooms, and the lack of large fish meant that fishermen emptied the Black Sea of small fish. This chain of events meant that a large ecological niche was empty, filled in a short time by jellyfish, which now dominate large parts of the Black Sea.

SHARKS IN TROUBLE

Populations of large sharks have fallen by more than 90 percent, and the situation is just as severe for large tuna and other top predatory fish. The massive decline affects life further down the food chain. Between 90 and 99 percent of 11 large shark species have disappeared in the Atlantic off the coast of the United States. All of these species hunt small sharks and rays, and biologists have recorded an increase in the populations of 12 out of 14 of the small shark and

ray species. These, in turn, have decimated local stocks of commercially important mollusks.

Facing no predation, cownose rays in the northwestern part of the Atlantic Ocean assumed a new position at the top of the food chain. For several years, the number of cownose rays increased by 9 percent a year, and today the population is up to more than 40 million.

Studies have shown that cownose rays can quickly decimate entire beds of Atlantic bay scallops. In Chesapeake Bay alone, the rays may consume up to 925,942 tons of scallops during the 100 days that the rays stay in the bay. The commercial catch of scallops in the bay has fallen to around 300 tons per year.

Farther to the south, overfishing has emptied most tropical coral reefs of top predator fish. The lack of predator control has caused a boom among smaller fish species and starfish, which are hunted by predators at natural coral reefs. In several places, the lack of top predators has probably contributed to an increase in the number of coral-eating starfish, as well as reduced the population of reef-building corals and algae.

SEA OTTERS HELP SEAWEED FORESTS

Sharks and other fish are not the only top ocean predators whose existence is threatened by humans. The sea otter

functions as a kind of ecological inspector of the seaweed forests of the North Pacific, but its numbers have declined drastically, due, in part, to the 19th-century fur trade. In the 1800s, when fur trappers almost wiped out sea otters, the seaweed forests also disappeared. Sea otters have a healthy appetite for sea urchins, and as otter numbers dwindle, the urchins blossom. The sea urchins devour the seaweed forests, which are the habitat of fry and a lot of marine life. Without sea otters to control the sea urchins, the latter often destroy the huge seaweed forests, which calm the waves, protecting the coast from erosion and allowing high-nutrient particles to sink to the bottom. Conservation efforts in the 20th century helped bring back the otters, and thus the seaweed and its ecosystem. But now sea otters face another danger. Lower fish stocks in the region have cut off the main food source for local seals and sea lions, which in turn were hunted by killer whales. Now killer whales have begun to hunt sea otters, and the seaweed forests are once again at risk.

PROBLEMS IN THE AIR

The top flying predators are also under pressure. Worldwide, populations of raptors, which includes eagles, vultures, hawks and owls, have declined because of destruction of habitats. In recent years, biologists have discovered that the decline is also affecting places where the raptors have traditionally had plenty of prey and space. In Burkina Faso, Mali and Niger, four large eagle species outside special protection areas have declined 86 to 98 percent over about a 30-year period, while another seven species may have disappeared altogether. And in western Kenya, raptors declined by 40 percent in just three years, with vultures and other scavengers making up the bulk of the loss. Scientists think that the raptor declines are due in part to an increase in human population and the associated takeover of land and resources. In other cases, scientists suspect that some of the birds may be feeding on dead lions, hyenas and other predators that were poisoned in an attempt to protect local livestock.

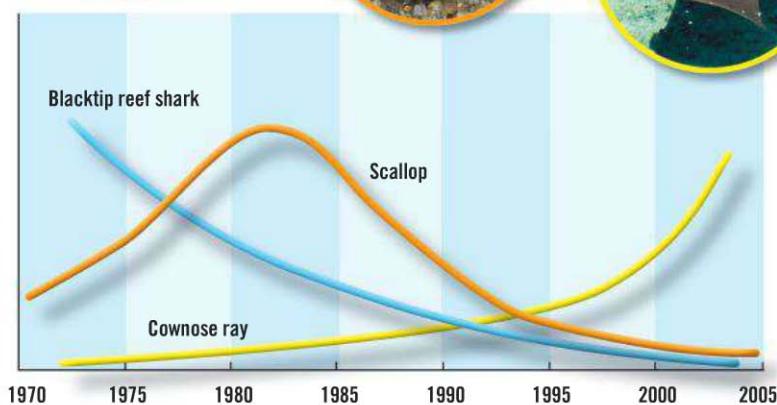
Biologists are studying how the decline of raptors affects the ecological order. A team of European biologists has found that territories with goshawks and

four owl species in the Italian Alps have a greater variety of trees, butterflies and small birds than similar woodlands without hawks and owls. The scientists speculate that the variety of species may mean a lot for an ecosystem's overall biodiversity.

Biologists are putting together a very complex puzzle in their efforts to find out how missing top predators affects the food chains on land, at sea and in the air; consequences manifest in countless ways, depending on the composition of the ecosystems. Sometimes, the lack of top predators only influences the next step in the food chain, but it often sends shock waves down through the entire ecosystem and affects the presence of everything from medium-size predators and herbivores to the smallest algae. Scientists hope that future research will explain more pieces of the ecological puzzle, leading to a concrete plan for the strategic reintroduction of predators in important places. 

FEWER SHARKS MEANS MORE RAYS

Since the 1970s, the population of sharks, including blacktip reef sharks, has declined off the east coast of the United States. The population of cownose rays, which are eaten by sharks, has thus exploded. Because the rays live on scallops, the population of Atlantic bay scallops has plummeted, and scallops fisheries have collapsed.



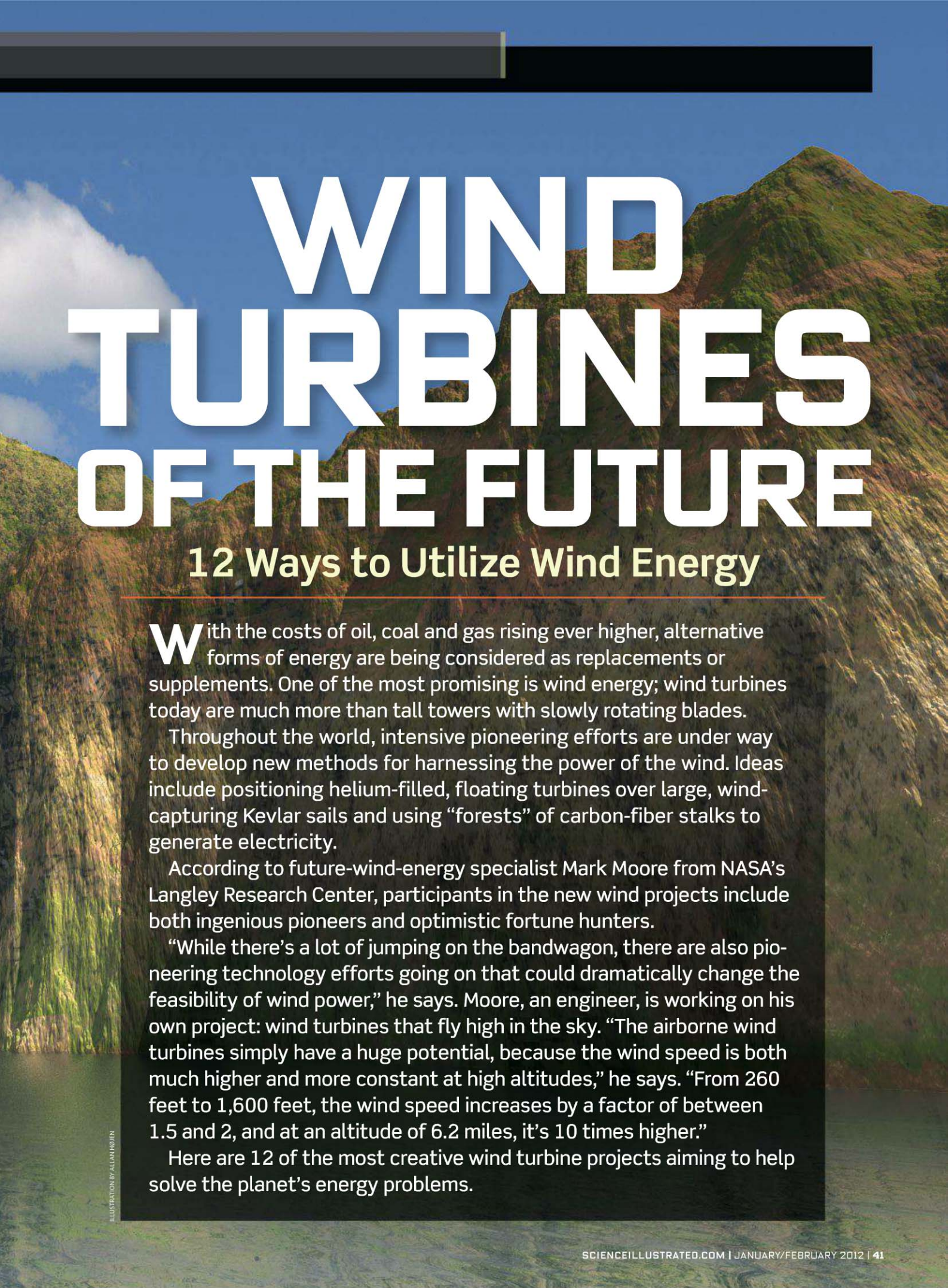
The absence of top predators means that the number of cownose rays has greatly increased in the northwestern Atlantic.

ON THE DRAWING BOARD

Wind Dam

Large Sail Captures Wind

Inventors of an approximately 17,000-square-foot Kevlar sail are currently seeking permission to place the wind catcher in a Russian valley. The sail, which resembles the spinnaker of a large yacht, is more than 80 feet tall and 245 feet wide, with a large turbine at the center. It's called a "wind dam" and was invented by the British architectural company Chetwoods Architects. The sail funnels the wind through a large central wind turbine supported by aluminum legs. Unlike traditional turbines, the dam makes optimal use of wind energy.



WIND TURBINES OF THE FUTURE

12 Ways to Utilize Wind Energy

With the costs of oil, coal and gas rising ever higher, alternative forms of energy are being considered as replacements or supplements. One of the most promising is wind energy; wind turbines today are much more than tall towers with slowly rotating blades.

Throughout the world, intensive pioneering efforts are under way to develop new methods for harnessing the power of the wind. Ideas include positioning helium-filled, floating turbines over large, wind-capturing Kevlar sails and using “forests” of carbon-fiber stalks to generate electricity.

According to future-wind-energy specialist Mark Moore from NASA’s Langley Research Center, participants in the new wind projects include both ingenious pioneers and optimistic fortune hunters.

“While there’s a lot of jumping on the bandwagon, there are also pioneering technology efforts going on that could dramatically change the feasibility of wind power,” he says. Moore, an engineer, is working on his own project: wind turbines that fly high in the sky. “The airborne wind turbines simply have a huge potential, because the wind speed is both much higher and more constant at high altitudes,” he says. “From 260 feet to 1,600 feet, the wind speed increases by a factor of between 1.5 and 2, and at an altitude of 6.2 miles, it’s 10 times higher.”

Here are 12 of the most creative wind turbine projects aiming to help solve the planet’s energy problems.

ALREADY IN USE

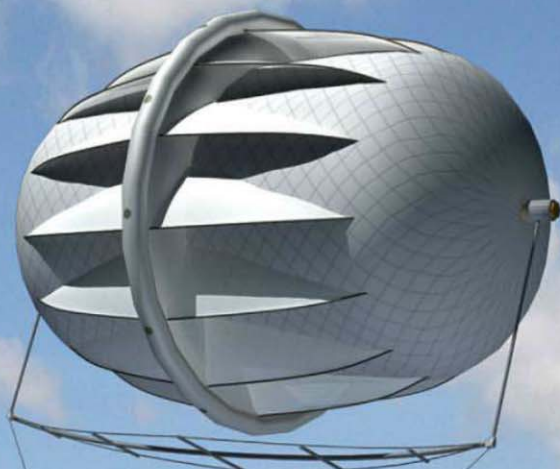
Windspire Turbine Fits Anywhere

Windspire is a 30-foot vertical turbine that rotates around its own axis. The turbine takes up very little space, making wind power a viable option for urban and suburban areas with limited land. The turbine can generate approximately 2,000 kilowatt-hours (kWh) a year in areas with annual average winds of 11 mph, and it is quiet. It costs roughly \$5,000, and with tax incentives that reduce that figure by up to 30 percent, it is affordable for both private individuals and companies.



WINDSPIRE ENERGY

IN THE TEST PHASE



Magenn Air Rotor System (MARS) Floating Turbine Captures High-Speed Winds

Magenn Power's floating, helium-filled wind turbine generates electricity by rotating around a horizontal axis, activating the built-in generator and stabilizing and providing additional lift for the turbine through the Magnus effect. The power generated is transferred down the tether to the Earth's surface, where it is either consumed or stored. The manufacturer says that it will be positioned at an altitude of 600 to 1,000 feet, and it can handle wind speeds up to 60 mph.

ALREADY IN USE

Energy Ball Shape Eliminates Noise

This spherical turbine with six curved rotor blades and a 3.6-foot diameter weighs around 66 pounds and is capable of generating electricity even at very low wind speeds. When the rotor blades rotate, the turbine resembles a sphere. The compact size and low noise mean that the turbines can be used to power private residences as well as larger urban areas.



P.TOLENIA/WWW.HAVVE-ENERGY.COM

IN THE TEST PHASE

Joby Airborne Wind Turbine Circles in the Wind Like a Kite

Joby Energy's flying wind farm is a kind of kite fitted with a number of small wind turbines with electricity-producing generators. The power is transmitted to Earth via a strong tether, which also holds the "kite" in place. It is carried up to an operating altitude of around 2,000 feet, where the strong pressure of the wind causes it to float and move in a constant circular motion. At this altitude, the nearly constant wind is typically 1.5 to three times stronger than at ground level.

JOBY ENERGY

ALREADY IN USE



J.F. BAGASCANIX

Bahrain World Trade Center A Part of the Structure

Three 65-ton wind turbines are mounted between the two towers of the 787-foot-tall Bahrain World Trade Center. The project is the first large commercial building that has integrated wind turbines into the structure. The turbines each have a 95-foot diameter, and depending on wind speed, they account for 11 to 15 percent of the twin skyscrapers' power requirement. The turbines generate 1,100 to 1,300 megawatt-hours a year.

IN THE TEST PHASE

Selsam Superturbine Turbine Blades Like Beads on a String

The offshore version of the Selsam Superturbine consists of a long, flexible carbon-fiber shaft anchored to the bottom of the ocean with a great number of small turbines mounted on the shaft. Inventor Doug Selsam has designed a number of wind turbines featuring many small turbine blades instead of a few large ones.

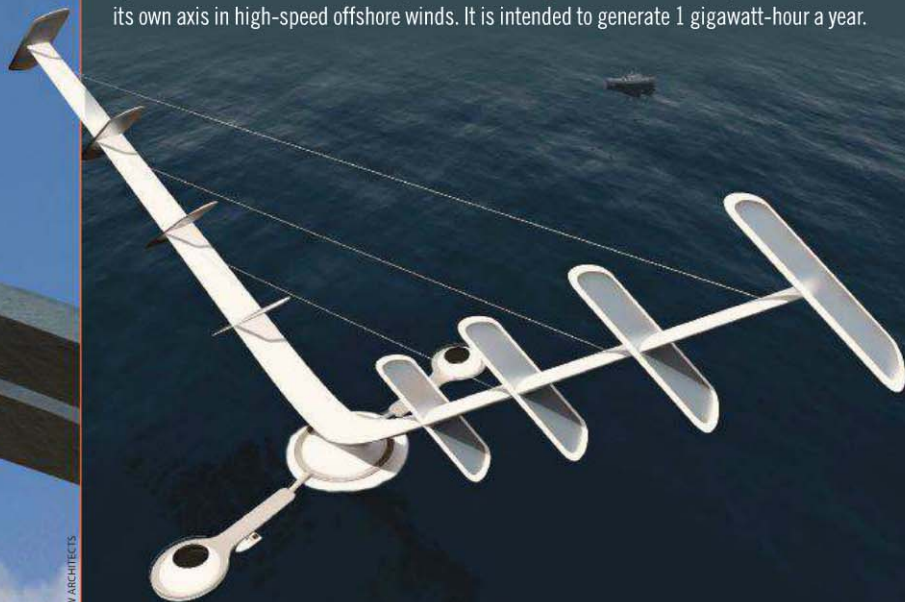
ILLUSTRATION BY ALAN H. HARRIS

ON THE DRAWING BOARD

NOVA

Large-Scale Offshore Wind Power Project

The British Novel Offshore Vertical Axis (NOVA) is an offshore wind turbine focusing on aerodynamics. The 120-foot-tall, V-shaped construction generates electricity by rotating around its own axis in high-speed offshore winds. It is intended to generate 1 gigawatt-hour a year.



GRANDSHAW ARCHITECTS

IN THE TEST PHASE

EdgeFlow

Right on the Edge

Developed by Danish engineers, the EdgeFlow wind turbine is meant to sit on the roof of a building, taking advantage of markedly accelerated wind after it hits a building and is forced to pass over it. A 118-foot-long horizontal turbine is mounted at the edge. One turbine can account for 30 to 35 percent of an average building's power consumption.



ON THE DRAWING BOARD

Solar Wind

Viaducts Full of Turbines

Solar Wind is a very different attempt at integrating wind turbines into existing structures. The concept, invented by three Italian architects, consists of placing a number of wind turbines between the bridge supports of the viaducts that dot the southern Italian landscape. According to the architects, a bridge with 26 wind turbines could generate 36 billion kWh a year. Moreover, the inventors recommended that the bridge be lined with solar cells, which would produce another 11.2 million kWh.



IN THE TEST PHASE

Sky WindPower

Flying Wind Turbine Resembles Helicopter

Sky WindPower engineers have invented a flying electric generator that resembles a helicopter. It is equipped with four large rotors that can lift the structure upward to where the wind is strongest. Once there, the strong winds rotating the blades will not only keep the turbine floating but will also generate electricity that is transferred back to Earth along the tether. Australian scientist Bryan Roberts originally developed the idea. Recent research suggests that if the turbine, with its speeds of more than 200 mph, operated in the jet stream, it could generate 10 to 50 times more electricity than turbines on the ground. The first prototypes have been tested on a smaller scale.

ILLUSTRATION BY ALLAN HEDJEN

ON THE DRAWING BOARD

Windstalk

Stalks Bend in the Wind

This “forest” of 180-foot-tall stalks could be built outside the planned city of Masdar in the United Arab Emirates. The stalks are filled with piezoelectric discs. When the stalks bend in the wind, the discs are forced together, and a generator at the root of the stalk creates energy. The stalks are made of carbon fiber and have a diameter of 30 cm and 5 cm at the base and top, respectively. They are silent and harmless. The tops of the stalks glow when the wind blows. In windless conditions, they are dark and look like an energy-producing art installation.



LOUISIANA IS SINKING

Though it may seem like a paradox, a *lack* of water could, in theory, drown coastal Louisiana. Every hour, an area of land approximately the size of a football field disappears. Mostly to blame are the extensive levees built along the edges of the Mississippi River to prevent flooding of the surrounding areas and maintain navigation routes, which means that the area does not have sufficient sediments to stay above water. Comprehensive plans have been made to save the endangered areas, and the first of them have already been implemented.



The road to the small island Isle de Jean Charles habitually floods. Soon, the entire island could be gone if measures aren't taken to protect the surrounding wetlands. Above: The New Orleans skyline is vulnerable to surrounding water.

TED JACKSON/TIMES-PICTURE/LEANDRO D. FRAZIER/SCANPIX (INSET); CLAUDE LOMAU (ILLUSTRATIONS)

Accelerated Wetlands Loss

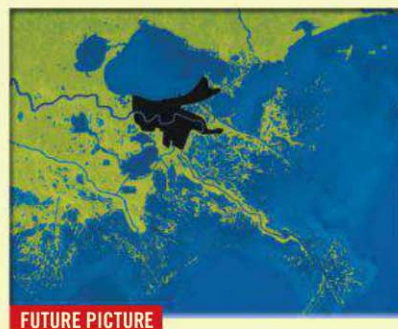
Pre-1930 The wetlands were thriving, but following the building of levees along the Mississippi River and channels through the marshes in the first half of the 20th century, the ecosystem rapidly degraded and the ground began to sink. Most maps today still depict the area as it appeared in 1930.



Today Louisiana is losing approximately 13 square miles of wetlands a year due to the lack of replenishing sediments from now stifled flooding, hurricanes and rising ocean levels. In 2005, Hurricanes Katrina and Rita swallowed 198 square miles of the state's wetlands, turning them into open water.

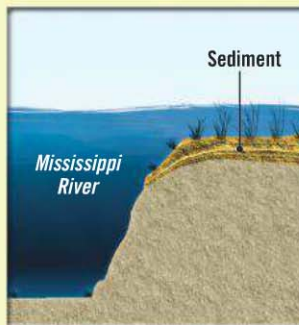


2060 Even accounting for current restoration efforts, scientists estimate that another 500 square miles of wetlands will disappear in the next 50 years, leaving New Orleans very vulnerable to the open sea, protected only by the levees that caused the steady sinking in the first place.



Levees and Channels Are to Blame

Since the 1930s, the Mississippi River has been trapped by a large number of levees built to stop frequent flooding and the surrounding wetlands cut into by river channels.



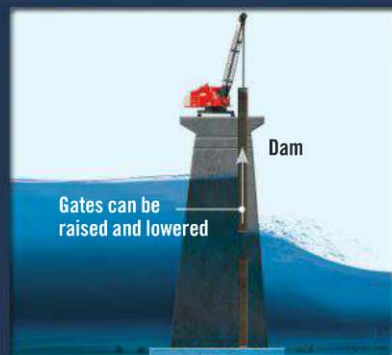
Before the Levees Generally, the region sank as the underlying soil settled. Though troublesome, the frequent flooding added much-needed sediment to the surrounding area and built upon the sinking soil, stabilizing the ground level.



After the Levees There's no more flooding, but no sediment is added, which means that the land sinks farther and farther below sea level.

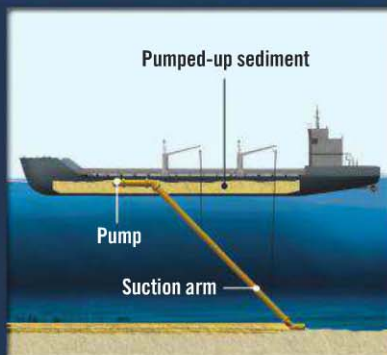
Water Builds Land

Many small projects are aiming to save Louisiana by allowing water, which contains nutrients and sediments that replenish wetlands, to run over the levees. The nutrients fertilize plants and bushes, whose roots hold onto the soil; the sediments are the building blocks of new land.



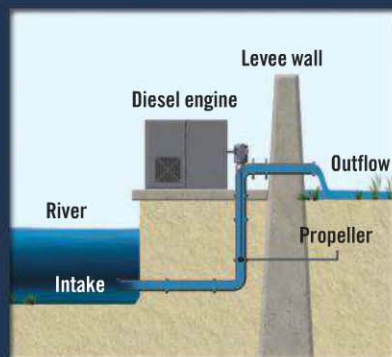
DAM AND LEVEE GATES

When the water level is high on the Mississippi River, water can be diverted through dam and levee gates, flooding the wetlands.



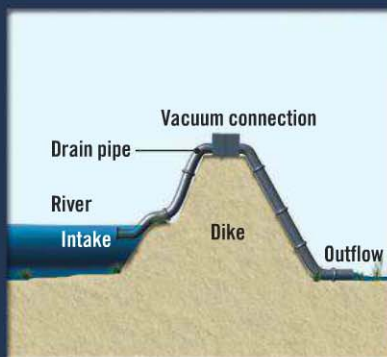
SEDIMENT-PUMPING DREDGERS

Louisiana's sediment-pumping dredgers function as suction cleaners. They transport sediments to deteriorated wetlands in an effort to rebuild the marsh.



PUMPING STATION

Engines pump water from the Mississippi River's canals under, through or over the canal walls and into the surrounding land.



DRAIN PIPES

Drain pipes divert water from the river. Because the outflow is lower than the intake, there is no need for pumps.

In April 2011, several barriers were opened after heavy rainfall made the Mississippi River water level rise.

Albert Naquin's home is often underwater. During the past six years, the southern Louisiana town he lives in has been flooded five times, and things only seem to be getting worse. Isle de Jean Charles is a small finger of land in the midst of one of the world's most vulnerable wetland areas. And every day, the open ocean of the Gulf of Mexico is moving a little bit closer to the battered houses.

Channels cut through the surrounding wetlands have weakened the buffer zone for hurricanes, and now storms submerge the land, slowly eating away at the isle. Where there used to be land, people now sail around in boats, and the only road leading to Isle de Jean Charles is underwater several times a year.

"The road is probably flooded 30 percent of the time," says Albert Naquin, tribal chief of the Biloxi-Chitimacha Indians, who have lived in the area for centuries. But 250 residents have left the community since 2002, leaving only 70 today, many of whom are considering leaving before it's too late. "Sooner

The Rescue Is Under Way

Many projects are being implemented to save coastal Louisiana. These five are among the biggest.

1. Myrtle Grove

While many other projects are moving sediments from the Mississippi River through pipelines to the endangered wetlands, this project in Myrtle Grove will divert the water and sediments from the river directly into the swamps. A dam with three gates, which can be opened and closed, will allow up to 45,000 cubic feet of sediment- and nutrient-laden water per second to flow into the surrounding land.

2. Bayou Dupont

Bayou Dupont used to be a marsh, but after the construction of several canals for industrial activities, the wetlands became open water. A number of pipelines taking bottom sediments from the river have added 577 acres of new land since May 2010.

3. Lake Hermitage

This fall, construction began on a project that will pump sediment from the Mississippi to Lake Hermitage's former wetland sites in an effort to add 593 acres of land. Natural dikes will also be built to protect the coastline against the constant invasion of salt water.



4. Barataria Basin

Tons of nourishing sediments have been moved to the swamps and marshlands by hydraulic dredging since March 2010. The project will eventually create an estimated 1,246 acres of new land.

5. Little Lake

In 2007, authorities finished the construction of a large project that has since added at least 488 acres of new land and prevented another 532 acres of marsh from disappearing. Sediments are taken from the bottom of Little Lake and sent through several pipelines to the endangered wetlands.

or later our community will die," Naquin says. "And with that, our Indian culture will die." The problem of lost land is unfortunately not unique to Isle de Jean Charles — Louisiana shrinks every day. The coastal wetlands, a unique ecosystem of marshlands and swamps filled with herons, alligators and trout, are being absorbed by the Gulf of Mexico — every hour, an area the size of a football field disappears. Since 1930, 1,829 square miles of land have been converted into open water, and the coast has crept closer to New Orleans. And most modern maps of Louisiana show the coastline as it appeared in the 1930s, so relying on a road map could make for a very watery drive.

"It's the largest land loss currently on the planet," says Val Marmillion, the managing director of America's Wetland Foundation, an organization fighting to save the wetlands.

The massive land loss is not only threatening to destroy an entire ecosystem, including dozens of endangered animal species, but it could also severely affect local residents as well as the greater U.S. economy. The fishing operations in the area, which account for an estimated 24 percent of the fish, crayfish and oysters consumed in the United

States, will likely be severely affected, and the oil and natural gas industry, which has an annual economic impact of \$385 billion and employs 1.3 million people, will be threatened. Finally, up to 2 million people are at risk of having to leave their homes. The problem is unfortunately not unique to Louisiana — most of the world's large river deltas are facing similar crises, derived largely from human development and modifications to the river's natural flow.

IMPACT OF THE LEVEES

In the late 1800s and early 1900s, New Orleans officials built up a levee system to protect the city from being inundated with water during the river's seasonal flooding. Then, in 1927, the rest of the Mississippi River watershed, from Illinois to Louisiana, experienced some of the worst flooding in American history, due to a year of heavy rains. Portions of 10 states along the river were underwater. The American authorities reacted promptly, passing legislation that enabled the federal government to manage flood risks countrywide. Approximately \$325 million was appropriated to construct floodways, spillways and diversion channels throughout the region.

What wasn't understood at the time,

though, were the negative impacts of such development, which was widespread at the time and carried out with little thought given to the natural environment. The levees and diversion systems cut the wetlands of Louisiana off from the Mississippi River, their source of life. Seasonal flooding is necessary in the life cycle for these wetlands, which are deeply dependent on the nutrients and sediments that the river brings along. The seasonal influx of fresh water also keeps salt water at bay, maintaining the low salinity levels that wetland plants need to survive. With its soft soils, southern Louisiana has always been sinking under its own weight, but new layers of mud created by river sediments compensated for the sinking, stabilizing ground levels and allowing the wetlands to flourish, which held the ocean at bay.

Coastal Louisiana has always been at the mercy of the Mississippi. The river is a dynamic builder, adding new land by depositing its sediments, but it has also left areas in a state of decay when it has been obstructed. The change before the levees were built, though, was gradual. In the past 5,000 years, the river has added an average of one to two square miles of land a year, up until the 1930s when the levees were built. Since then,



The Mekong Delta is a lifeline in Vietnam. Dams also threaten to cause the entire area to sink into the ocean.

approximately 13 square miles of land have been lost a year.

Both natural nutrients that fertilize the marsh plants and artificial ones from industrial complexes and agriculture — such as nitrate — are now being carried downstream, leaking into the Gulf of Mexico. That has created dead zones, where all life has disappeared because of oxygen depletion. As salt water invades the wetlands, freshwater plants die because of the high salt content, and without their roots, the soil slowly erodes. And in 2005, Hurricanes Katrina and Rita dealt another devastating blow, transforming 198 square miles of marsh into open water. Even with restoration efforts, scientists estimate that another 500 square miles could turn into ocean by 2060. By then, New Orleans will be close to open water, protected from future storm surges and ocean level rises only by its levees, which are already vulnerable because of riverbank erosion. The unfortunate irony is that the wetlands themselves would protect against flooding, had they not been cut off from the Mississippi River. When a hurricane or storm surge hits, the wetlands function like a sponge, absorbing huge quantities

of water and energy. Without this vital natural landscape, the levees must be taller, which leads in turn to further sinking of the soft soil.

MISSISSIPPI RIVER BEGINS TO MAKE A COMEBACK

Steve Mathies, the executive director of the Louisiana Office of Coastal Protection and Restoration, is trying to save Louisiana from the Gulf of Mexico. Realizing that something drastic had to be done, the Louisiana authorities in 2007 prepared a master plan setting guidelines for preserving the wetlands. Geologists, scientists and engineers from all over the world are presently compiling new ideas to be included in an updated master plan to be finished in 2012. The key is the muddy water of the Mississippi.

"The Mississippi River is both a blessing and a curse," Mathies says. Even though it brings life to the region, it is also the indirect cause of the crisis, and it is essential that the river be given more space, so that it can once again flow into the wetlands and make the marsh retreat. The code word, he says, is diversion, which will slowly let the river flow into the marshlands by constructing a number of gates

at the top of the levees, allowing water to flow through at high tides.

Another possibility is using large pumps to move water, sediments and nutrients from the river directly into the wetlands. The difficulty is in finding the right combination of mega-projects that could make a real difference but will take a long time to construct and small projects that make a difference immediately. Because, while the clock is ticking, more and more land disappears into the Gulf.

"If we wait to build the massive diversion projects, we'll lose everything we have," Mathies says. "We have to think long term, but also have to think about tomorrow and next month." Some tough choices will have to be made, however, since not everything can be saved. Some of the diversion projects will probably flood areas where some people live now.

"We can't save it all," Mathies says. "The best we can do is look at what areas we can save and sustain for the long term and invest in them. But the areas we can't save, we can't invest in those. If we do that, we'll lose it all."

Many other countries will closely watch the rescue plan for the Mississippi Delta. Just as in Louisiana, many of the

world's large river deltas are sinking, including those of the Nile, the Mekong, the Ganges and, to some extent, the Rhine, because of human intervention and activities. Each is vulnerable to flooding and storms and could potentially put the lives of hundreds of millions of people at risk. To address these concerns, America's Wetland Foundation organized an international conference in New Orleans in October 2010, with the aim of bringing together scientists, decision makers and engineers from all over the world to address the problem.

NO RIVER OF MONEY

The biggest challenge to saving the Mississippi Delta is monetary. There's no agreed upon figure for completion of Louisiana's restoration projects, but the U.S. government has earmarked \$80 million annually for the restoration. Yet many scientists and advocates say that more is needed to save the ecosystem. Still, many locals see this as a small victory,

as it is the first time that the government recognizes the problem financially. The cleanup after Hurricane Katrina and its aftereffects cost an estimated \$200 billion, but if nothing is done to save the wetlands, in time an even bigger disaster may be the result.

"It requires an engineering feat, but we can figure it out," Mathies says. He says that the resources that the nation risks losing "greatly outweigh the investments."

For Albert Naquin and the rest of Isle de Jean Charles' inhabitants, the current state of affairs means that they may soon be the first climate refugees in United States history. They work against the clock, as the Gulf of Mexico continues to erode the coast. In Naquin's opinion, the Biloxi-Chitimacha tribe will soon be scattered across the country. "Wherever they move, people will marry the locals, and our Indian blood will disappear," he says. "In a few years, our tribe will no longer exist." **SIG**

THREATS LOOM EVERYWHERE

Louisiana is not the only place where deltas are heading toward disaster because of damming. According to the U.N. Intergovernmental Panel on Climate Change, the Nile, the Mekong, the Ganges and the Rhine deltas are particularly threatened.

In Vietnam's Mekong Delta, several million people are affected. The river has been dammed to a great extent in order to protect against flooding, water rice fields or build power plants that convert the power of the river to electricity. As in Louisiana, salt water has started to invade wetlands, hurting the rice harvest. Twelve new dams are planned along the river in Laos and Cambodia, and they would be disastrous for the delta downstream, which could be swallowed by the ocean.

In the Netherlands' Rhine Delta, the problem is less severe, but the authorities have realized how important it is to intervene. The government has introduced a plan called "Room for the River," reducing or eliminating the dams and dikes, thus letting the rivers flood, and protecting flood plains. In the extensive Noordwaard Project, the outer dam has downsized, while canals have been constructed to control flooding.

Satellites Reveal the Crisis

Thanks to satellite images, the United Nations can closely monitor how the world's largest river deltas lose ground to the ocean.



The best view of the world. Here, American astronaut Tracy Caldwell Dyson looks down on Earth through the ISS's observation cupola. She spent six months at the ISS.

ORBITING EARTH ABOARD THE

ISS



Astronauts aboard the International Space Station (ISS) experience 16 sunrises and just as many sunsets over the course of a single day. For a brief moment, the atmosphere lights up, creating a visual symphony of thin colored ribbons. Between the light changes, the astronauts can observe deserts, rain forests and oceans passing by quietly. And on the horizon, they can often see flaming auroras. In 2003, astronaut Don Pettit told NASA's Science News online news feed: "We flew through an auroral curtain over Canada. The station was surrounded by a dimly glowing red fog. Just below were green rivers of light. It was like I had been shrunk down to some miniature dimension and inserted into a tube of a neon sign."

Since an observation cupola was mounted on the ISS in 2010, it has become even easier for astronauts to enjoy the scenery. From the station, astronauts can photograph buildings, highways and even small lagoons. Observing the Earth from space also makes it easier to see changes to the globe. An important part of the astronaut's job is to document these changes — a particularly striking image comes from the burning of the world's rain forests, which is occurring constantly. Astronauts also witness earthquakes, tsunamis and volcanic eruptions. And now earthbound observers can get a space-eye view as well, thanks to the thousands of photos taken from the ISS.

PHOTOS: NASA/SPL/SCANPIX

The ISS is slightly smaller than a football field and has winglike solar arrays, which convert sunlight to direct current power. This power is then stored via battery and is used to power tools and other electronic devices that span nearly 300 feet. The astronauts' living quarters are about the size of a six-bedroom house.



AUSTRALIA • GREAT BARRIER REEF

Tiny Animals Create a Giant Organism

The world's largest coral reef system, the Great Barrier Reef, consists of 2,900 smaller reefs. The water — a series of Pacific Ocean inlets — is dark blue; the scattered coral islands are green or white. The Great Barrier Reef extends more than 1,250 miles, and it is the largest structure of living creatures on the planet.

More than 200 people have spent short or long periods of time at the ISS. Around 140 were from the United States, but astronauts from a total of 15 different countries have visited. Seven tourists have paid for a visit to the ISS.



EGYPT • THE NILE

Egypt's Vital Waterway Shines

Proximity to water has historically affected where people can live. This is especially evident along the Nile River, whose life-giving water has enabled Egyptians to inhabit the area for thousands of years. The surrounding desert and the Sinai Peninsula toward the east are almost totally dark, while the cities of Israel can be seen to the far right.



USA • SOUTHERN CALIFORNIA

Fires Blur the Atmosphere

In 2003, large wildfires ravaged a vast area in Southern California; hundreds of homes were destroyed and 15 people died. It was the state's largest-ever wild land fire. Streaks of smoke from forest fires and the burning of rain forests can be seen clearly from the ISS.



An area of law referred to as “space law” governs what happens if a serious crime, such as murder, is committed at the ISS. If such a thing were to happen, the suspect would be prosecuted in his or her home country.

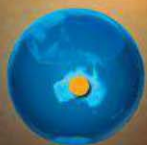


USA • DENVER

United States Is World's Largest Showcase

Astronauts always know when they're flying above the United States; no other country emits as much light into space at night. Many American cities also differ from those of other countries in that their design has been carefully planned from the start, producing a characteristic street grid. This is Denver, where only the downtown area breaks the established pattern.

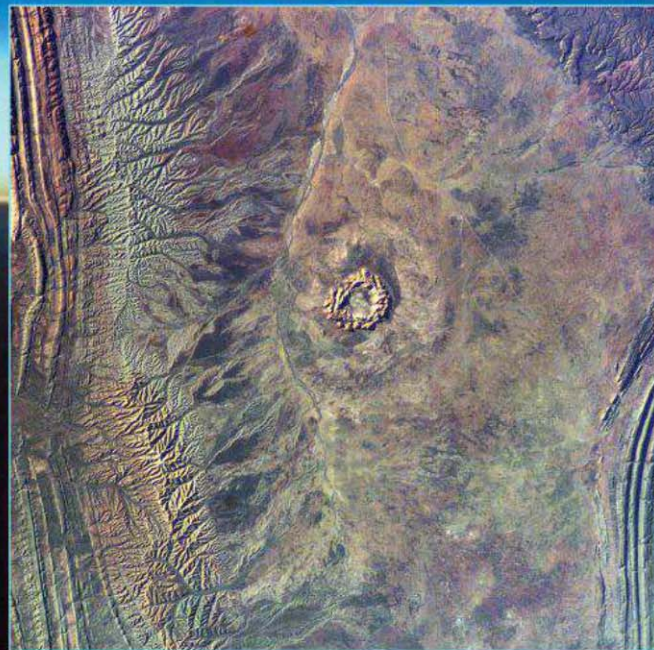
The space station is 357 feet long and weighs 893,344 pounds.
It took 13 years to build and cost a total of \$37 billion.



AUSTRALIA • NORTHERN TERRITORY

Desert Climate Has a Preserved Crater

Meteor craters only survive on Earth in regions that have been deserts for millions of years. In central Australia, the Gosses Bluff crater was formed 142 million years ago when a meteor struck Earth. The crater is located between two mountain ranges and measures 15 miles in diameter.



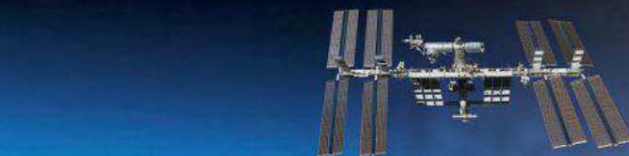
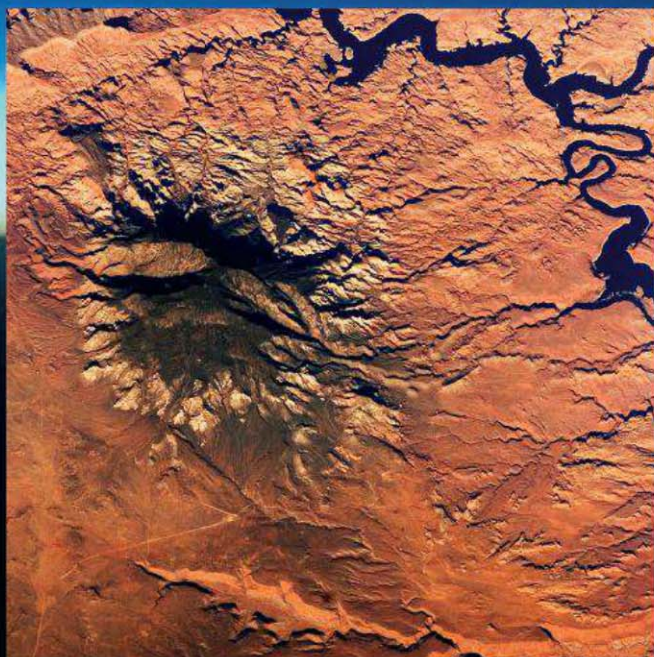
WESTERN AFRICA • SENEGAL/MALI

Tropopause Makes Clouds Flat

Cumulonimbus clouds are dense, heavy and huge. This magnificent one, photographed at the border between Senegal and Mali, is flat at the top. This occurs because the tropopause, the region between the meteorologically active troposphere and the drier stratosphere above, traps the cloud.



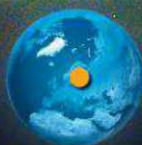
Because of the absence of gravity, visits to the toilet in space entail the collection and retention of liquid and solid waste by airflow, which is used to suction them up. Solid waste is collected and stored until the astronauts get back to Earth. Liquid, however, is ejected into space, where it vaporizes.



USA • UTAH

Utah Desert Has Martian Landscape

Human flight missions to Mars will not likely be realized in the near future, but when the ISS passes over the red rocks of Utah, the astronauts get a sense of what a flight above the red planet might be like. The peak is the 10,388-foot Navajo Mountain, where igneous rock, which forms when molten earth hardens, has emerged through an overlaying sedimentary layer.



SOUTHERN FINLAND

Electric Phenomenon Produces Magic Lights

Auroras are among the most cherished experiences for many astronauts. The red and green carpets of light are formed when electric particles from the sun, directed by the Earth's magnetic field, collide with atoms in the atmosphere, emitting light. This photo was taken above Finland. The largest light spot in the center is Helsinki.

Astronauts are subjected to stronger radiation than people on Earth. Space radiation, which includes cosmic rays as well as particles from the sun and from the Earth's magnetic field, can damage human tissue and lead to a litany of health problems. NASA monitors astronauts' radiation exposure on the ISS.



RUSSIA • THE KURIL ISLANDS

Volcano Erupts Its Way Through the Clouds

Sometimes, volcanic eruptions can be so violent that the column of smoke, vapor and ash breaks through the clouds and creates a hole in the cloud cover. Some volcano experts suspect that that is what happened to the clouds surrounding the Sarychev volcano (pictured above). The volcano erupted in June 2009, and the ash cloud caused some disruption in the air traffic between East Asia and North America.

Water plays a vital role on Earth. Life cannot exist without water, and at the same time, water has many peculiar qualities.

WATER FROM HEAD TO FOOT

Most of the body consists of water. In young men and women, water constitutes 60 and 55 percent of body weight, respectively. The difference is due to women having more fatty tissue with a lower water content.



Women
55%

Men
60%

Infants
78%

Top Athletes
60-65%

10.9 cups

of perspiration per hour is not unusual for a tennis player.



70% of the brain consists of water.

Some people in developing countries only get **7.9 gallons** of water for all their daily needs — the equivalent of a five-minute shower in an American household.

7 days is, at most, how long a person can survive without water. Without food, we can survive one month.

53 gallons

of water is how much a camel can drink in one hot day. The water is stored in the camel's bloodstream, not in its humps.



10 days

is the average length of time that water molecules are in the air before falling as rain, snow or condensation.



2 to 3 mm

is the usual maximum size of raindrops, before air resistance causes them to break up into smaller drops.

884 million

people — one in eight living today — don't have access to safe drinking water.



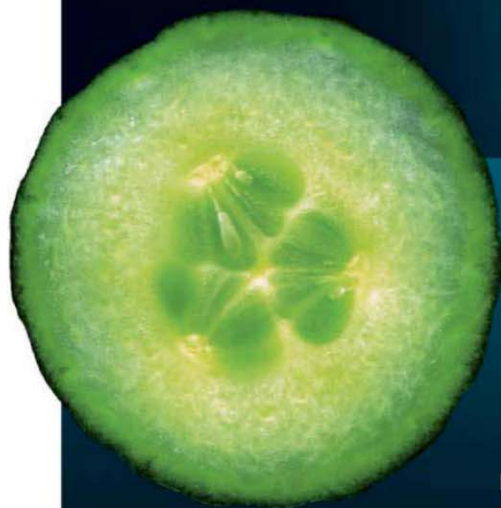
1 drop

of water per second from a dripping toilet causes water waste of **2,642 gallons** per year.

In Riyadh, Saudi Arabia, **6 out of 10 gallons** never reach consumers, because of leaky pipes. In Singapore, **6 percent** of water is lost to leaks.

FOOD IS FILLED WITH WATER ...

All foods contain water, even those that seem very dry.



Cucumbers
95 grams per 100 grams



Potatoes
80 grams per 100 grams



Salted peanuts
1 gram per 100 grams



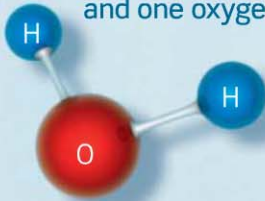
Corn flakes
4 grams per 100 grams



Bananas
75 grams per 100 grams

WATER ON EARTH

33,000,000,000,000,000,000,000,000
water molecules make up 4.2 cups of water.
One water molecule consists of two hydrogen atoms
and one oxygen atom.



At any given moment,
3,100 cubic miles
of water are locked in
the atmosphere in the
form of clouds or
humidity.

At **39.2** degrees
Fahrenheit, liquid water
has the highest density.
Out of millions of
chemical compounds,
water is the only one of
which the liquid state is
heavier than the solid.

105 gallons
is how much a large oak
tree can evaporate per day.

13%, or one-eighth, of an iceberg is
above the water.



87% beneath.

... AND REQUIRES WATER TO BE HARVESTED AND PREPARED



898 gallons of
water are used
to produce 2.2
pounds of rice.



37 gallons of
water are needed
to produce one cup
of coffee.

4,094 gallons of water
go into producing 2.2
pounds of beef.



1.7% of the
world's water is
groundwater.

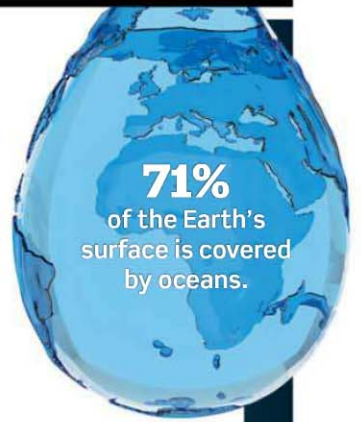
0.022%
is bound by
ground ice
and permafrost.

0.013% is
in lakes.

0.001% is
moisture in the
Earth's soil.

0.0008% is in swamps.

0.0001% is "biological water,"
i.e., water in plants and animals.



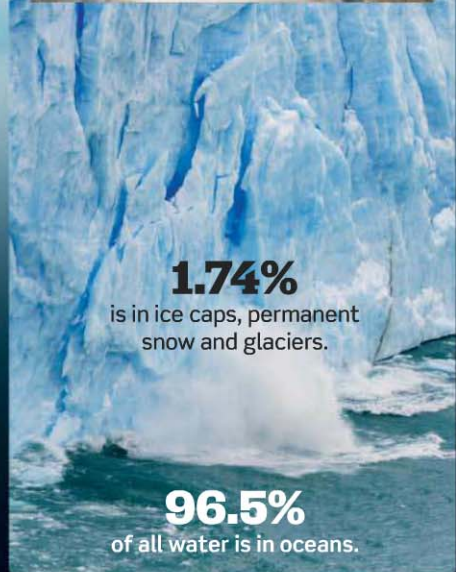
71%
of the Earth's
surface is covered
by oceans.



0.001%
of the world's water is
in the atmosphere.



0.0002%
is in rivers.



1.74%
is in ice caps, permanent
snow and glaciers.

96.5%
of all water is in oceans.

EARN MORE POINTS BY
USING FEWER CLUES

5 POINTS

4 POINTS

3 POINTS

2 POINTS

1 POINT

1. CHEMISTRY
NAME THESE
SUBSTANCES

These slippery, bitter substances are defined as molecules or ions that can accept protons from an acid.

Touching these to litmus paper will turn the paper blue. Often, a pH meter is used.

Sodium hydroxide (NaOH), also known as caustic soda, lye or drain cleaner, is one example.

These substances, which are found in many cleaning agents, could be described as the opposite of acid.

The name of these substances is derived from the Latin word *basis*, meaning bottom or foundation.

2. GEOGRAPHY
NAME THIS PLACE

The highest peak of the region, Mount Darwin, measures nearly 8,000 feet.

In 1881, the two countries that share this archipelago agreed on its border, although some islands are still being disputed.

The two principal cities are Porvenir (Chile) and Ushuaia (Argentina), the southernmost city in the world.

Cape Horn, located here, is often incorrectly credited as South America's southernmost point.

This archipelago got its name from the Portuguese seafarer Magellan in 1520 and means "land of fire."

3. ZOOLOGY
NAME THIS ANIMAL

This animal comes from the order Chiroptera. There are more than 1,100 species.

One of the species, *Craseonycteris thonglongyai*, is the world's smallest known mammal. It weighs less than seven hundredths of an ounce.

This animal uses echolocation — orientation through sound — to navigate and hunt.

In 1874, Johann Strauss II composed an operetta, *Die Fledermaus*, named after this animal.

This animal can fly, and Batman is named after it.

4. FAMOUS PEOPLE
NAME THIS MAN

This man was born in 1856, the son of a wool merchant in Pribor, which was then part of the Austrian Empire. He died in London in 1939.

He studied medicine at the University of Vienna, where he observed the psychotropic effects of cocaine.

He published several works; one of the most significant is *The Interpretation of Dreams*, published in 1899.

His patients would lie on a couch during therapy, which remains a popular symbol of psychotherapy.

The first name of this man, the father of psychoanalysis, is Sigmund. His surname resembles the German word for joy.

5. TECHNOLOGY
NAME THIS RIDE

Pittsburgh engineer George W. G. Ferris first constructed one of these on a large scale in 1893.

The 541-foot-tall Singapore Flyer, opened in 2008, is the tallest one in the world.

In Orson Welles' film *The Third Man*, there is a dramatic conversation on one of these — the Wiener Riesenrad, which is located in Vienna.

The ride is most commonly seen in amusement parks. Riders move around a lot, but do not get very far.

In English, it is named after its inventor.

6. HISTORY
NAME THIS YEAR**ITALY, MARCH 16**

The Italian politician Aldo Moro is kidnapped on a street in Rome by members of the terrorist group the Red Brigades; 54 days later, he is murdered.

UNITED KINGDOM, JULY 25

The world's first test-tube baby, Louise Joy Brown, is born healthy by a planned Caesarean section at Oldham General Hospital.

THE VATICAN, OCT. 16

Cardinal Karol Wojtyla of Poland is elected the 264th pope of the Roman Catholic Church, taking the name John Paul II after his predecessor, who was pope for only 33 days.

Correct Year = 5 points
± 2 years = 4 points
± 4 years = 3 points
± 6 years = 2 points
± 8 years = 1 point



AP/PHOTO



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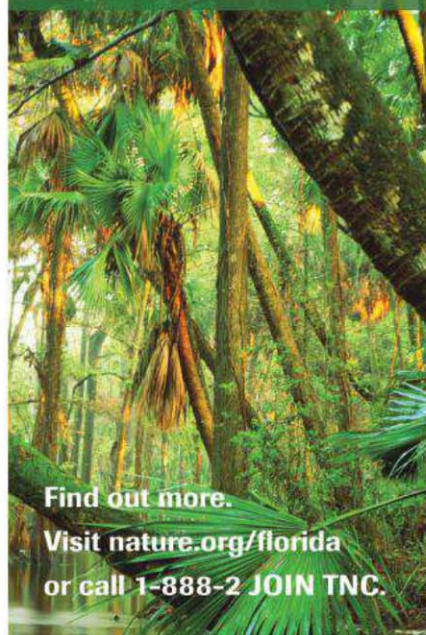
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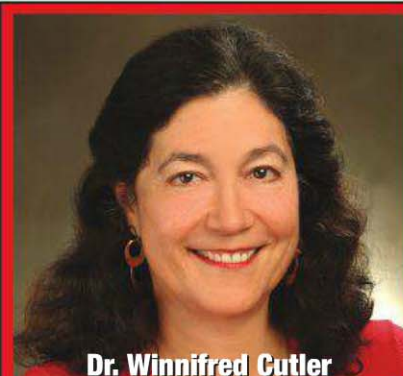
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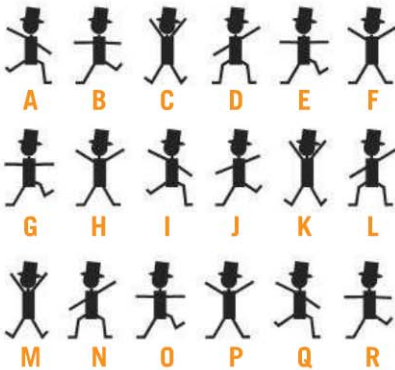
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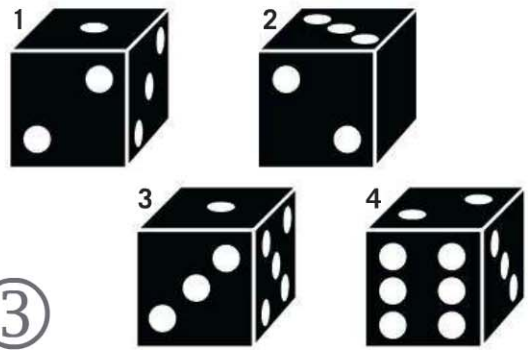
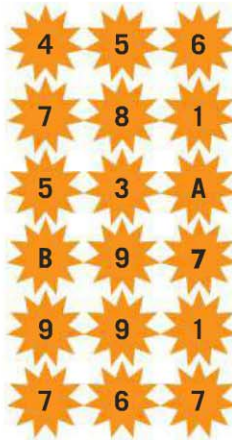
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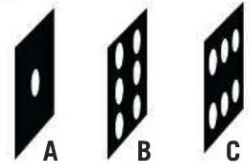
- ① Which figure stands out from the rest?



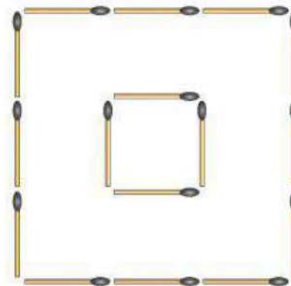
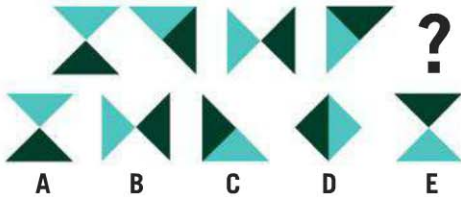
- ② Which numbers should replace A and B?



- ③ Figures 1, 2, 3 and 4 show four views of the same die, except that one face of figure 2 is blank. Which of the following should replace the blank face?



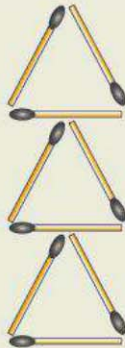
- ④ Find the next figure in the sequence.



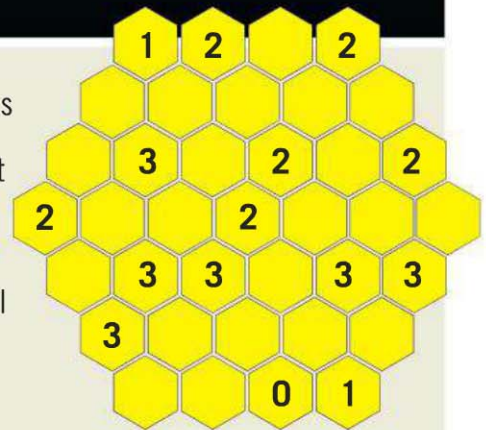
- ⑤ Move four matches so that these two squares become three.

HEAD BREAKERS

- ① Move three matches so that the three equilateral triangles become four equilateral triangles.



- ② Color some of the hexagons according to a certain system. The hexagons that contain a number should not be colored. The numbers tell you how many of the adjacent hexagons will be colored in the end.



- ③ I have a number of coins in my right pocket and a number in my left pocket. The square of the number in my right pocket plus the cube of the number in my left pocket is 368, but the cube of the number in my right pocket plus the square of the number in my left is 174. How many coins do I have in each pocket?

- ④ In each line, the number in parentheses is determined by the two outside numbers by using a simple rule. Determine the rule and use it to fill in the empty pair of parentheses.

12 (27144) 3
13 (64169) 4
14 (125196) 5
15 () 6

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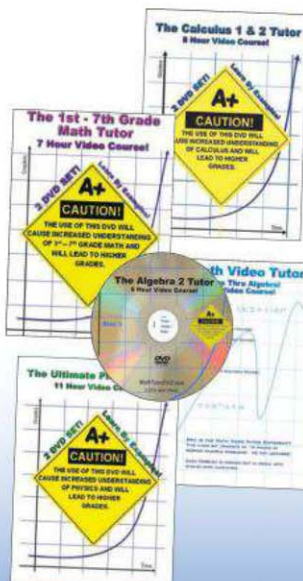
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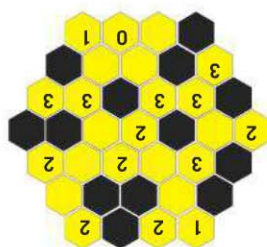
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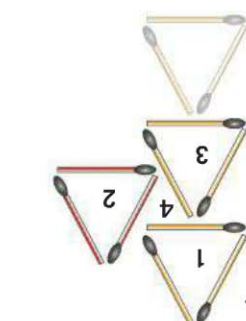
ANSWER KEY

4 216, 225. The square of the number on the left goes inside the parenthesis on the right and the cube of the number on the right goes inside the parenthesis on the left. Since $15^2 = 225$ and $6^3 = 216$, we get 216, 225.

3 Right = 5, Left = 7. Checking this, we have $5^2 + 7^2 = 25 + 49 = 74$.



2 See diagram.



HEAD BREAKERS p. 64



5 There are two different solutions.

4 E. The light and the dark triangles take turns rotating 90 degrees counterclockwise. First the dark, and then the light one.

3 C. In figures 1 and 4, the two faces adjacent to both the two-dot and three-dot faces are the one-dot and six-dot faces, so blank must one of these. It cannot be the one-dot face, however, because that would be inconsistent with figure 1, so blank has six dots. In figure 4, the aisle between the two rows in the six-dot face does not lead toward the three-dot face, and that eliminates B.

2 A = 9 and B = 2. With these choices, the row totals will be consecutive numbers: 15, 16, 17, 18, 19 and 20.

1 J stands out. There are at least three copies of every figure except J, but J matches none of the others.

BRAIN TRAINERS p. 64

TRIVIA COUNTDOWN p. 62
Problem 1: Bases; Problem 2: Tierra del Fuego; Problem 3: Bat; Problem 4: Sigmund Freud; Problem 5: Ferris Wheel; Problem 6: 1978



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With the aid of scientific research over the years, people have learned that the functioning of natural laws controls their resulting right or wrong output when their input conforms to that specific law or instead is somehow noncompliant.

Examples with regard to laws of physics such as gravity, chemistry, and electricity probably come to mind.

Since the created laws of physics are autonomous and self-enforcing, people have learned to carefully conform to each law of physics to ensure their safety and well-being.

What only a comparatively few people have learned is that there is a little-known, overweening natural law that controls the right or wrong results that develop from our every thought and action.

In the past century, the late Richard W. Wetherill identified a ***natural law of behavior*** that he and now a group of his former students have been presenting to the public for several decades. But despite the fact that nearly 300,000 people worldwide have visited our Website as of October 2011, more people are needed that understand the law's basic message and will help by sending others to our Website: alphapub.com.

Nature's behavioral law is also autonomous and self-enforcing as evidenced by people's failures to resolve their wrong results, destroying one civilization after another.

The use of every philosophical, scientific, practical, or religious approach of man did not nor could not resolve society's escalating problems and trouble. Today, levels of crime, corruption, mental disorders, and rebellious rioting continue

spiraling upward in our growing population. What a depressing list of wrong results!

But, "Be of good cheer, the solution is here." It is found in ***creation's natural law of absolute right*** mentioned above.

Could the entire human race have been consistently defying that natural law for eons? The brief answer is "yes." And that defiance is stopped only when people accord to nature's behavioral law, calling for their attitude and behavior to comply with creation's law of absolute right.

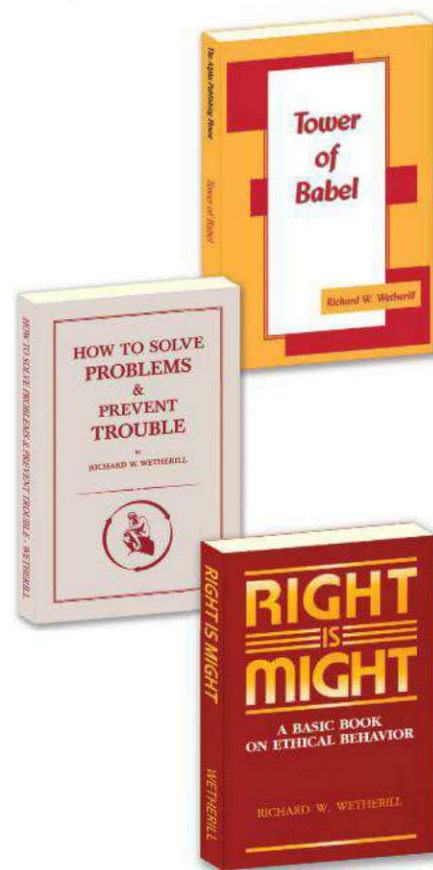
In order to survive, this civilization must conform to the creator's formula for life, calling for behavior that the ***law deems is rational and honest*** in what is thought, said, and done.

Prevalent blocks preventing people from conforming are their desires to get their way or to get notoriety and credit for what they believe are ***their*** efforts: money, careers, and prominent positions. All such prideful behavior is inappropriate when you consider that everybody's very existence is a gift of creation.

There needs to be a realization that in the end, people have been paying with their lives for their misbehavior regarding the law of absolute right.

That tells it like it is!

Whether anybody likes it or not, only rational, honest people are able to serve the purposes of creation's plan of life.



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